Saskatchewan
Environment

Hydrology Branch

1981 Operation of the Saskatchewan River System

March 1984
HYD-6-49

This report has been prepared primarily for internal use by Saskatchewan Government agencies. Material should not be used without approval.

1981 OPERATION OF THE SASKATCHEWAN RIVER SYSTEM

HYD-6-49

R.J. Blain, C.E.T.
Engineering Assistant II

D.R. Richards, P. Eng.
Head
Operations Division
Hydrology Branch
Saskatchewan Environment

March, 1984

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	iii
LIST OF FIGURES	iv
Chapter	
I. INTRODUCTION	1
A. GENERAL	1
B. CONDITIONS AT THE END OF THE 1980 CALENDAR YEAR	1
C. REPORT OUTLINE	2
II. INFLOW SUMMARY AND WATER SUPPLY FORECASTS	3
A. GENERAL	3
B. FORECASTS	4
III. RESERVOIR DIVERSIONS AND LOSSES	8
A. GENERAL	8
B. EAST SIDE PUMP PLANT	8
C. QU'APPELLE RIVER DAM RELEASES	8
D. EVAPORATION LOSSES	9
E. TOTAL DIVERSIONS AND LOSSES AT LAKE DIEFENBAKER	13
F. MISCELLANEOUS DIVERSIONS FROM THE NORTH AND SOUTH SASKATCHEWAN RIVERS	14
G. TOBIN LAKE LOSSES	15

Chapter		Page
IV.	GENERATING STATION OPERATION	17
	A. COTEAU CREEK	17
	B. SQUAW RAPIDS	18
	C. ENERGY GENERATED	21
V.	SPECIAL CONDITIONS	23
	A. GENERAL	23
	B. RAIN STORMS AND SPILLWAY USE	23
	C. FLOOD CONTROL	25
	D. CRITICAL EVENTS AND DECISIONS	26

Appendix A

HISTORICAL DEVELOPMENT AND OPERATING CRITERIA FOR THE SASKATCHEWAN RIVER SYSTEM

LIST OF TABLES

		Page
1.	NORTH AND SOUTH SASKATCHEWAN RIVERS AVERAGE MONTHLY FLOWS FOR 1981	4
2.	SOUTH SASKATCHEWAN RIVER WATER SUPPLY FORECAST SUMMARY OF 1981 INFLOW TO LAKE DIEFENBAKER	6
3.	NORTH SASKATCHEWAN RIVER WATER SUPPLY FORECAST SUMMARY OF 1981 FLOWS AT PRINCE ALBERT	7
4.	1981 AND HISTORIC (1967-80) WITHDRAWALS THROUGH EAST SIDE PUMP PLANT	10
5.	1981 AND HISTORIC (1967-80) QU'APPELLE RIVER DAM RELEASES	11
6.	1981 SUMMARY OF WATER BALANCE FOR LAKE DIEFENBAKER	12
7.	1981 SUMMARY OF WATER BALANCE FOR TOBIN LAKE	16
8.	MEAN MONTHLY RELEASES FROM GARDINER DAM	19
9.	SASKATCHEWAN RIVER SYSTEM ANNUAL POWER GENERATION IN RECENT YEARS	21
10.	1981 MONTHLY DISTRIBUTION OF SASKATCHEWAN RIVER SYSTEM POWER GENERATION	22

LIST OF FIGURES

1. KEY MAP OF THE SASKATCHEWAN RIVER SYSTEM

2. KEY MAP OF LAKE DIEFENBAKER

3. KEY PLAN OF GARDINER DAM

4. AREA AND CAPACITY CURVES FOR LAKE DIEFENBAKER

5. KEY MAP OF SQUAW RAPIDS PROJECT

6. AREA AND CAPACITY CURVES FOR TOBIN LAKE

7. NOVEMBER 1980 TO APRIL 1981 PER CENT OF NORMAL PRECIPITATION OVER THE SASKATCHEWAN RIVER SYSTEM

8. MAY TO OCTOBER 1981 PER CENT OF NORMAL PRECIPITATION OVER THE SASKATCHEWAN RIVER SYSTEM

9. LAKE DIEFENBAKER 1981 INFLOW, OUTFLOW AND LAKE ELEVATION

10. NORTH SASKATCHEWAN RIVER 1981 PRINCE ALBERT HYDROGRAPH

11. KEY PLAN OF SASKATOON SOUTHEAST WATER SUPPLY SYSTEM

12. TOBIN LAKE 1981 INFLOW, OUTFLOW AND LAKE ELEVATION

13. MAY 4 TO 10, 1981, ALBERTA PRECIPITATION IN MM

14. MAY 11 TO 17, 1981, ALBERTA PRECIPITATION IN MM

15. JUNE 8 TO 14, 1981, ALBERTA PRECIPITATION IN MM

16. JULY 6 TO AUGUST 10, 1981, ALBERTA PRECIPITATION IN MM

17. EFFECT OF REGULATION DURING 1981 AT LAKE DIEFENBAKER ON SOUTH SASKATCHEWAN RIVER FLOWS

18. EFFECT OF REGULATION DURING 1981 AT LAKE DIEFENBAKER AND TOBIN LAKE ON FLOWS IN THE SASKATCHEWAN RIVER BELOW SQUAW RAPIDS

Chapter I

INTRODUCTION

A. GENERAL

This report describes the flows and operations that occurred on the Saskatchewan River system in Saskatchewan for the calendar year 1981. The operations at Lake Diefenbaker and Tobin Lake are the main focus of the report. A key map of the river system is shown on Figure 1.

B. CONDITIONS AT THE END OF THE 1980 CALENDAR YEAR

Flows in the fall of 1980 on the South Saskatchewan River and on the North Saskatchewan River were above normal. South Saskatchewan River flows were above normal in the spring and below normal in the summer of 1980. Lake Diefenbaker reached a maximum elevation of 556.28 metres (m) while Tobin Lake approached its maximum storage capacity. By December 31, 1980, water use during early winter had drawn Lake Diefenbaker to an elevation of 553.63 m, compared to the fsl of 556.87 m and Tobin Lake to an elevation of 313.41 m compared to the fsl of 313.64 m.

Flows in the South Saskatchewan River above Lake Diefenbaker in December, 1980, averaged 80 cubic metres per second (m^3/s) and the North Saskatchewan River at Prince Albert averaged 128 m^3/s. The normal December flows are 110 m^3/s and 115 m^3/s respectively for these locations.

C. REPORT OUTLINE

This report outlines the flows and operations for the 1981 calendar year at Lake Diefenbaker and Tobin Lake. The first chapter provides a general introduction. The second chapter describes the flows that occurred and the water supply forecasts that were developed for operation planning at various times throughout the year. The remaining chapters of the main text discuss the operation of the generating stations, the consumptive withdrawals, the Qu'Appelle River Dam releases and special operation problems encountered in 1981. A detailed documentation of the historical development on the Saskatchewan River system in Saskatchewan and operation criteria can be found in Appendix A.

Figures 1 to 6 show some key maps of the Saskatchewan River system, the Gardiner and Squaw Rapids dams and the storage characteristics of the lakes behind both dams.

Chapter II

INFLOW SUMMARY AND WATER SUPPLY FORECASTS

A. GENERAL

The year 1981 was a somewhat above normal runoff year on the Saskatchewan River system, with the North Saskatchewan River at Prince Albert at approximately 115 per cent of normal and the South Saskatchewan River Lake Diefenbaker inflow at approximately 130 per cent of normal. In each case the flows reflect the seasonal precipitation which is illustrated on Figures 7 and 8.[1]/ Figure 9 shows the South Saskatchewan River inflows and outflows for Lake Diefenbaker and reservoir elevations. Figure 10 shows the North Saskatchewan River flows at Prince Albert.

The average flow of the South Saskatchewan River into Lake Diefenbaker for 1981 was 292 m^3/s compared to the normal of 220 m^3/s.

The average flow of the North Saskatchewan River at Prince Albert for 1981 was 259 m^3/s compared to the normal of 225 m^3/s.

The average monthly flows of the North and South Saskatchewan Rivers for 1981 are listed in Table 1.

1/ Precipitation during November and December, 1980 was mostly snow that did not melt until 1981. Similarly, precipitation in November and December of 1981 is not included in this report because it contributed to the 1982 runoff.

Table 1

NORTH AND SOUTH SASKATCHEWAN RIVERS
AVERAGE MONTHLY FLOWS FOR 1981

Month	North Saskatchewan River at Prince Albert (m^3/s)		South Saskatchewan River below Red Deer River (m^3/s)	
	Recorded	Normal	Recorded	Normal
January	121	130	127	90
February	109	125	135	100
March	117	115	174	130
April	286	340	168	275
May	364	340	682	340
June	400	395	824	640
July	328	395	514	390
August	613	225	467	180
September	259	225	154	130
October	182	210	89	135
November	177	100	111	125
December	149	115	53	110
Average	259	225	292	220

NOTE: Normals shown are based on 1975 level of development in Alberta.

B. FORECASTS

Forecasting procedures developed by Water Survey of Canada for the Prairie Provinces Water Board were employed for forecasting water supply on the Saskatchewan River system in 1981. The 1964 Saskatchewan Water Resources Commission forecasting procedures were used as confirmation. The River Simulating Package (SIMPAK) developed by Environment Canada was also employed for streamflow simulation.

Forecasts were updated monthly and operation plans adjusted as required based on these forecasts. Because future climatic events are unknown and difficult to predict at the time that a forecast is made, each forecast included the following:

1) best estimate - based on recorded precipitation and flows to the first day of the forecast month and normal precipitation to the end of the forecast period;
2) lower quartile estimate - based on recorded precipitation and flows to the first day of the forecast month and lower quartile precipitation to the end of the forecast period; and
3) upper quartile estimate - based on recorded precipitation and flows to the first day of the forecast month and upper quartile precipitation to the end of the forecast period.

These lower and upper quartile values were used in operation planning to assure that plans based on the "best estimate" forecast did not include decisions that would be irreversible if smaller or larger flows were to occur. The forecasts of water supply are summarized in Table 2 and Table 3 for the South Saskatchewan and North Saskatchewan Rivers respectively.

Table 2

SOUTH SASKATCHEWAN RIVER
WATER SUPPLY FORECAST SUMMARY OF
1981 INFLOW TO LAKE DIEFENBAKER

	Flow Forecast Prepared in the Month of:												
Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Recorded
Jan.	90												127
Feb.	100	100											135
Mar.	120	130	120										174
Apr.		280	240	180									168
May		350	320	260	240								682
June		600	580	520	450	650							824
July		350	340	290	260	380	500						514
Aug.		180	170	140	130	160	250	500					467
Sept.		130	120	100	90	120	170	190	150				154
Oct.		130	130	100	100	120	150	170	140	90			89
Nov.										100	100		111
Dec.										100	100	110	53

Note: Numbers in the body of the table show the values forecasted on the first day of the forecast month.
Values in the right hand column are the recorded flows for comparison.

Monthly mean flow (m^3/s)

Table 3

NORTH SASKATCHEWAN RIVER
WATER SUPPLY FORECAST SUMMARY OF
1981 FLOWS AT PRINCE ALBERT

	Flow Forecast Prepared in the Month of:												
Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Recorded
Jan.	100												121
Feb.	130	130											109
Mar.	130	120	100										117
Apr.		300	280	280									286
May		350	310	240	240								364
June		390	370	290	290	350							400
July		360	320	250	250	270	250						328
Aug.		230	230	200	200	200	200	670					613
Sept.		230	230	190	180	180	200	250	250				259
Oct.		190	190	170	160	160	170	190	190	180			182
Nov.										120	130		177
Dec.										100	100	120	149

Note: Numbers in the body of the table show the values forecasted on the first day of the forecast month. Values in the right hand column are the recorded flows for comparison.

Monthly mean flow (m^3/s)

Chapter III

RESERVOIR DIVERSIONS AND LOSSES

A. GENERAL

For the purposes of this report, only diversions and losses that remove water from the Saskatchewan River system in Saskatchewan are considered. Diversions and losses from Lake Diefenbaker include the East Side Pumping Plant, the Qu'Appelle River Dam releases and evaporation. At Tobin Lake, evaporation losses are calculated however no analysis has been made on the residuals from the water balance. Withdrawals from above and below the lakes for irrigation and water supply are considered to be negligible.

B. EAST SIDE PUMP PLANT

Water is withdrawn from Lake Diefenbaker by Saskatchewan Agriculture through its pumping facilities near the east end of Gardiner Dam. This water is used for irrigation in the Outlook area and to supply industrial, municipal and other users through the Saskatoon Southeast Water Supply System. Figure 11 shows the locations of these users.

Table 4 summarizes withdrawals through the East Side Pump Plant for the years 1967 to 1981.

C. QU'APPELLE RIVER DAM RELEASES

Water supply requirements on the Qu'Appelle River system for municipal, industrial recreation, irrigation and other uses may be

augmented with releases at the Qu'Appelle River Dam as directed by the Qu'Appelle Operation Board.[2]

Releases were made from the Qu'Appelle River Dam in 1981 to satisfy municipal and other requirements. During the summer months Eyebrow and Buffalo Pound Lakes received water from the Saskatchewan River system. Considerably above normal flows were required to meet the municipal requirements on Buffalo Pound Lake and downstream irrigation demands. In total, 142 140 cubic decametres (dam^3) of water was released to the Qu'Appelle River in 1981, the highest total for any year since the Qu'Appelle River Dam was built. The monthly distribution of these releases is shown in Table 5.

D. EVAPORATION LOSSES

A detailed study of evaporation from Lake Diefenbaker for 1981 was undertaken by the Atmospheric Environment Service.[3] The evaporation losses that were determined in that study, using Meyer's equation, were combined with precipitation [4] over the reservoir to determine the net evaporation estimates shown in Table 6.

2/ This Board is appointed by the Minister of Saskatchewan Environment and has representation from Saskatchewan Environment, Saskatchewan Tourism and Renewable Resources, Saskatchewan Agriculture, PFRA and the Qu'Appelle Management Board Public Advisory Committee.

3/ R. F. Hopkinson. Temperature and Evaporation on Lake Diefenbaker 1981 and 1982, Hydrometeorological Report No. CSS-R83-01, In Preparation.

4/ Based on the average of the following meteorological stations: Birsay, Elbow, Glenside, Herbert, Strongfield, Swift Current, Tugaske, Pennant and Shackleton.

Table 4

1981 AND HISTORIC (1967-80)
WITHDRAWALS THROUGH EAST SIDE PUMP PLANT

Year	Pumped Quantity (Dam^3)								Annual Total Dam^3
	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	
1967	0	0	0	15 240	19 580	20 190	21 640	10 110	86 760
1968	0	1 650	8 040	11 840	940	80	0	0	22 550
1969	0	4 310	12 880	6 030	2 210	1 190	0	0	26 620
1970	0	710	2 560	6 540	2 170	480	20	0	12 480
1971	0	4 450	5 260	8 700	2 480	2 900	1 230	0	25 020
1972	0	7 820	8 940	13 500	11 200	9 070	1 130	0	51 660
1973	8 240	7 610	11 790	13 260	13 260	12 000	300	0	66 460
1974	0	0	5 130	13 120	5 090	250	3 780	0	27 370
1975	0	6 700	12 030	17 060	7 450	9 410	0	0	52 650
1976	0	7 450	8 970	12 050	13 100	1 860	0	0	43 430
1977	0	11 460	16 800	33 750	14 330	11 150	0	0	87 490
1978	0	10 290	21 640	27 860	16 390	12 340	0	0	88 520
1979	0	410	9 030	28 300	16 730	9 250	0	0	63 720
1980	0	16 850	26 650	35 420	16 280	15 650	0	0	110 850
1981	0	20 300	14 860	35 160	16 850	19 610	0	0	106 780
Avg.	550	6 670	10 970	18 520	10 540	8 360	1 870	670	58 160

Table 5

1981 AND HISTORIC (1967-80)
QU'APPELLE RIVER DAM RELEASES

Year	Monthly Releases (Dam^3)												Annual Total (Dam^3)
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1967	0	0	0	70	50	3 430	12 210	15 450	13 370	14 980	15 350	13 590	88 500
1968	12 530	4 350	1 950	5 300	9 550	11 840	11 950	1 360	80	70	18 440	11 720	89 140
1969	11 770	2 500	0	0	40	50	7 060	4 160	10 700	1 250	6 540	7 540	51 610
1970	0	0	0	50	60	90	90	90	100	430	7 230	7 140	15 280
1971	4 290	3 080	280	60	620	80	110	1 440	260	3 860	6 650	3 790	24 520
1972	3 790	2 860	460	130	12 450	9 480	16 520	10 650	2 830	1 580	8 700	3 790	73 240
1973	3 790	230	650	14 170	17 060	3 400	14 760	15 980	1 720	5 480	4 380	3 490	85 110
1974	3 320	770	90	120	150	120	530	1 610	110	110	8 940	4 930	20 800
1975	3 790	2 890	90	110	110	1 050	2 510	5 250	5 810	4 260	4 340	4 250	34 460
1976	4 090	930	140	150	320	520	1 330	2 100	7 080	3 750	4 530	4 030	28 970
1977	2 860	2 700	3 060	3 210	9 850	9 940	8 190	9 250	8 710	8 850	3 890	3 280	73 790
1978	3 240	2 280	180	130	1 400	2 310	7 200	10 280	9 760	5 030	3 420	3 550	48 780
1979	3 340	2 850	60	100	290	740	2 880	8 820	9 620	4 600	3 630	3 420	40 350
1980	3 400	3 030	280	260	3 890	17 370	19 010	15 440	10 070	4 660	4 660	4 970	87 040
1981	4 750	2 680	2 070	10 370	25 920	27 130	26 960	22 030	12 360	1 560	2 940	3 370	142 140
Avg.	4 330	2 080	620	2 280	5 450	5 840	8 750	8 260	6 170	4 030	6 910	5 520	60 250

Table 6

1981
SUMMARY OF WATER BALANCE FOR LAKE DIEFENBAKER

Months	Inflow		Outflow			Change in Storage		Difference
	South Sask. River	Local	Net Evaporation	Total Diversions	Outflow South Sask. River	From Water Balance	From Change in Water Elevation	
January	341 540	2 070	0	12 360	812 160	-480 910	-412 470	68 440
February	328 490	23 240	0	9 500	640 310	-298 080	-368 340	-70 260
March	446 210	3 540	0	9 680	402 280	57 790	33 650	-24 140
April	437 180	1 640	9 420	17 020	408 930	3 450	-55 070	-58 520
May	1 829 000	690	20 390	53 910	409 100	1 346 290	1 057 770	-288 520
June	2 136 500	1 900	5 010	49 330	1 273 800	810 260	853 420	43 160
July	1 377 480	1 810	32 490	69 640	966 040	311 120	162 890	-148 230
August	1 252 450	1 210	59 790	46 480	1 249 690	-102 300	-78 710	23 590
September	400 120	1 120	65 660	39 310	639 710	-343 440	-322 840	20 600
October	240 710	1 380	36 810	9 160	519 180	-323 060	-343 860	-20 800
November	290 220	1 640	20 820	10 280	572 140	-311 380	-340 510	-29 130
December	142 300	1 040	4 230	10 970	618 450	-490 310	-503 950	-13 640
Total	9 242 200	41 280	254 620	337 640	8 511 790	179 430	-318 020	- 497 450

Monthly volume (dam^3)

E. TOTAL DIVERSIONS AND LOSSES AT LAKE DIEFENBAKER

Table 6 provides a month-by-month listing of the inflows to, outflows from and changes in storage at Lake Diefenbaker during 1981. The "difference", in the table represents the difference between change in storage calculated using the water balance, and the change in storage calculated using the apparent change in water level.

If all the measurements in the water balance were precise, the difference would have to be the ground water gain or loss factor. Lake Diefenbaker raised the water level in 240 kilometres of the South Saskatchewan River Valley by an average of 25 metres. While this rise in water level caused adjustments in the ground water levels in the immediate area, the valley remains a discharge point in the regional ground water regime.[5/] Thus, charging the overall loss of water (497 450 dam^3) to ground water must be rejected and other explanations for the difference must be identified.

The simplest explanation would be that the annual differences are a net result of measurement error. This 497 450 dam^3 would require less than 6 per cent error in the flow record. Since this difference resulted from a balance of inflow and outflow it would represent about 3 per cent error in each component. Hydrometric data collection agencies would accept that as a good standard of accuracy. Since two components of the water balance, evaporation and precipitation, were arrived at by indirect calculations, a greater error could be

5/ Van Everdingen, R.O., 1972, Observed changes in Ground Water Regime Caused by the Creation of Lake Diefenbaker, Saskatchewan, Inland Waters Branch, Department of the Environment, Ottawa.

assigned to these and the flow measurement portion of the balance could be considered better than 6 per cent accurate.

The monthly differences are less easily accommodated: they are too large to be explained by climatic and hydrometric measurement error alone. It has been concluded that the storage factor used in the water balance may be too small because:

1) the reservoir could be slightly larger than the capacity curve suggests, particularly at the upper levels of the shoreline where erosion has taken place; and
2) bank storage, that is, the movement of water into the soils of the reservoir bank while the lake fills and the return of this water as the lake drains, would also create a greater storage capacity than the impervious reservoir assumed for the water balance.

F. MISCELLANEOUS DIVERSIONS FROM THE NORTH AND SOUTH SASKATCHEWAN RIVERS

The Cities of Saskatoon and Prince Albert, towns such as Outlook and St. Louis and a number of private irrigation schemes in Saskatchewan use the water of the Saskatchewan River system. However, because of return of effluent and the small size of these withdrawals in comparison to total flows, their net effect is quite small. For example, the City of Saskatoon withdraws approximately 1 m^3/s and returns approximately 80 per cent of this as effluent. For that reason these miscellaneous diversions are not considered in this report.

G. TOBIN LAKE LOSSES

Table 7 provides a month-by-month listing of the inflows to, outflows from and change in storage at Tobin Lake during 1981. The "differences" in the table represent the amount by which the surface water balance failed to balance with the apparent change in storage.

A detailed study of evaporation from Tobin Lake for 1981 by the Atmospheric Environment Services[6/] is also considered. The evaporation losses that were determined in that study, using Meyer's equation, were combined with precipitation[7/] over the reservoir to determine the net evaporation estimates.

6/ R. F. Hopkinson. Evaporation from Tobin Lake 1981 Hydrometeorological Report No. CSS-R82-03, December, 1982.

7/ Based on the meteorological station: Nipawin.

Table 7

1981
SUMMARY OF WATER BALANCE FOR TOBIN LAKE

Months	Inflow	Outflow		Change in Storage		Difference
	Saskatchewan River	Net Evaporation	Sask. River	From Water Balance	From Change in Water Elevation	
January	1 111 450	0	1 241 910	-130 460	- 68 890	61 570
February	922 220	0	966 300	25 920	54 140	28 220
March	768 440	0	975 970	-207 530	-161 590	45 940
April	1 262 220	0	1 449 620	-187 400	135 780	323 180
May	1 107 300	12 270	1 241 140	-146 110	-159 900	-13 790
June	2 358 550	2 590	2 194 300	161 660	120 250	-41 410
July	1 696 810	10 110	1 738 450	-51 750	31 160	82 910
August	2 894 570	30 840	2 763 420	100 310	31 340	-68 970
September	1 419 210	22 030	1 404 860	-7 680	-22 840	-15 160
October	1 105 320	4 580	1 038 440	62 300	43 530	-18 770
November	1 045 870	4 750	1 029 970	11 150	-2 970	-14 120
December	923 100	0	793 410	129 690	-88 710	-218 400
Total	16 685 060	87 170	16 837 790	-239 900	-88 700	151 200

Monthly volume (dam^3)

Chapter IV

GENERATING STATION OPERATION

A. COTEAU CREEK

Ice began to form on the South Saskatchewan River below Gardiner Dam towards the end of November, 1980. Flows were increased to 250 m^3/s December 1, 1980, with restrictions on fluctuations to allow for a safe freeze up operation. Towards the end of December, 1980, a winter operation plan was implemented and stayed in effect until mid-April, 1981.

With a below normal mountain snow pack, and a reservoir elevation of 551.49 m on May 1, 0.76 m above normal, outflows were reduced to 50 m^3/s on May 4, 1981. Mid-May rain storms in Alberta caused flows into Lake Diefenbaker to rise to 1 840 m^3/s in late May. Power generation was brought up to plant capacity (400 m^3/s), still 200 m^3/s had to be spilled from Lake Diefenbaker for nine days in order to stay within rate-of-rise guidelines in filling the reservoir.

Rain storms continued through June, 1981, and caused flow into Lake Diefenbaker to peak at 1 020 m^3/s in mid-month. Again 200 m^3/s had to be spilled for eleven days. From near the end of May to near the end of June, 1981, power generation was running at near plant capacity (400 m^3/s). In early July releases for power generation fluctuated

between 300 and 400 m^3/s but by the end of the month discharges through the spillway were resumed to accommodate high inflows resulting from rainstorms in the headwaters. From July 31 to August 9 discharge through the spillway was at a rate of approximately 300 m^3/s because of relatively high flows and little storage left in the reservoir to store inflows. Lake Diefenbaker elevation crested in mid-August at elevation 556.83 metres, 0.04 metres below FSL.

From mid-August, 1981, to late fall power generation releases remained relatively high but did gradually recede. Starting mid-November SPC released flows between 200 m^3/s and 300 m^3/s for power generation and without slugging restrictions. Due to mild weather it was mid-way through December before freeze up operations in the 250 m^3/s range began with restrictions on hourly and daily fluctuations. In early January, 1982, freeze up was judged adequate to go into full winter operation.

On December 31, 1981, the elevation of Lake Diefenbaker was 552.78 metres, compared to 553.57 metres, January 1, 1981. Inflow, outflow and lake elevations are shown graphically on Figure 9. Table 8 shows the mean monthly outflows from Lake Diefenbaker at Gardiner Dam for the period 1969 to 1981.

B. SQUAW RAPIDS

In January there were problems with power generation at the Poplar River Power Station at Coronach. Consequently, SPC requested that

releases of 600 m^3/s from Tobin Lake be permitted for 3 days, January 7 to 9, inclusive. As a result of these operations water appeared at the edges of the river at the traffic crossing located at Cumberland House, however, no major inconveniences occurred. Releases from Squaw Rapids generating station then returned to the 400 - 500 m^3/s range. Once again on January 22, 1981, flows were increased to 700 m^3/s for one day to meet power requirements. Permission was granted for only one day at 700 m^3/s with one more day to return to more normal flows. From then on there were relatively normal operations at Squaw Rapids until the end of the winter.

During May and June, 1981, Squaw Rapids releases were limited to the generating plant capacity (900 m^3/s) even though there was water being spilled at Coteau Creek. Rains in Alberta over both the North and South Saskatchewan River basins towards the end of July forced spilling at Squaw Rapids of over 500 m^3/s for the first eleven days of August. Once these large flows passed,relatively normal operations were conducted at Squaw Rapids for the remainder of the year

Flows on the North Saskatchewan River were 130 percent of normal through the summer while flows on the South Saskatchewan River were 150 percent of normal. The Saskatchewan River consequently had above normal summer flows.

The inflow, outflow and lake elevations are shown graphically on Figure 12.

C. ENERGY GENERATED

The amount of energy generated is usually a function of the magnitude of flow in the Saskatchewan River system. In 1981 power generation at Coteau Creek was considerably more than in 1980 because of large inflows to Lake Diefenbaker. Squaw Rapids also generated more power in 1981 than in 1980. Table 9 shows the comparative power generation levels for recent years. The monthly distribution of generation in 1981 is shown in Table 10. The water rental paid in 1981 by the Saskatchewan Power Corporation to the province was $428 746 for Coteau Creek and $504 680 for Squaw Rapids.

Table 9

SASKATCHEWAN RIVER SYSTEM
ANNUAL POWER GENERATION IN RECENT YEARS

Year	Energy at Coteau Creek (MWH)*	Energy at Squaw Rapids (MWH)
1968	200 900	790 000
1969	1 123 800	1 236 200
1970	823 500	1 047 300
1971	900 900	1 166 400
1972	1 131 600	1 243 600
1973	733 700	1 005 100
1974	1 074 000	1 363 100
1975	978 700	1 077 800
1976	836 600	935 400
1977	469 100	807 800
1978	726 800	1 040 000
1979	676 700	925 800
1980	667 300	1 023 800
1981	1 042 600	1 227 200
Avg.	813 300	1 063 500

* MWH - Megawatt-hours

Table 10

1981 MONTHLY DISTRIBUTION OF
SASKATCHEWAN RIVER SYSTEM POWER GENERATION

Month	Coteau Creek Generating Station (MWH)*	Squaw Rapids Generating Station (MWH)
January	104 787	96 144
February	81 534	74 670
March	51 938	74 750
April	52 415	108 760
May	41 726	96 340
June	131 236	116 650
July	125 783	127 710
August	131 212	165 570
September	88 194	102 850
October	72 977	78 630
November	78 650	75 860
December	82 098	59 260
TOTAL	1 042 550	1 227 194

* MWH - Megawatt-hours

Chapter V

SPECIAL CONDITIONS

A. GENERAL

The preceeding chapters describe the operation of the Saskatchewan River system in general terms and indicate overall monthly operation characteristics.

Some special conditions occurred which had to be dealt with during the year. Water supply forecasting and long-term operation planning is supplemented with shorter-term operation planning. The agencies involved in planning operations monitor flows and water use on a week-to-week basis and during critical periods on a day-to-day basis. The following sections describe those periods in 1981 when the day-to-day operation planning dealt with special conditions.

B. RAIN STORMS AND SPILLWAY USE

A major storm throughout the entire headwaters area from May 4 to 8 added from 75 to 175 mm of water equivalent to the snowpak. Another storm on May 15 and 16 in the headwaters of the Oldman River added a further 50 to 175 mm of precipitation. See figures 13 and 14. In response to these events releases from Lake Diefenbaker were increased on May 22 and water was spilled over the spillway starting on May 26 and continuing until June 4. The maximum rate of outflow in this period was 600 m^3/s; 400 m^3/s through the power plant and 200 m^3/s spill through the spillway. At Saskatoon the maximum flow realized was 580 m^3/s while the peak inflow to Lake Diefenbaker was 1840 m^3/s.

Before spilling began aerial reconnaissance flights were made from Gardiner Dam to the confluence with the North Saskatchewan River to ensure that no damage would result from high flows. Water users along this reach were contacted so that they could move pumps or other equipment which might be affected.

Another storm on June 8 to 14 in the headwaters of the Bow and Oldman Rivers resulted in precipitation accumulations of 50 mm to 150 mm. See Figure 15. The spillway was operated again on June 14 to release 200 m^3/s for a total release of 600 m^3/s. This release continued until June 26 when the spillway gates were again closed. Peak flows at Saskatoon from this storm without Lake Diefenbaker in place would have been 1025 m^3/s whereas the recorded peak was 560 m^3/s.

A further series of storms centered over the Bow, Red Deer River and North Saskatchewan River Basin in July and early August resulted in total precipitation in these regions of 100 mm to 200 mm. See figure 16. The final storm, centered over the Red Deer basin caused the peak flow for the year on the Red Deer River.

A spill was started on July 29, at Coteau Creek, gradually increasing to 330 m^3/s on July 31 for a total discharge of 730 m^3/s. The spill continued until August 10 when the spillway gates were closed. For this event the peak flow at Saskatoon would have been 890 m^3/s had Lake Diefenbaker not been in place, whereas the recorded peak was 665 m^3/s.

These same July and August rains resulted in high flows on the North Saskatchewan River resulting in a combined peak into Tobin Lake of over 1600 m^3/s which required releases of 1500 m^3/s at Squaw Rapids. A spill of 500 m^3/s was started at Squaw Rapids on August 1. Spilling decreased gradually until August 15 when the spillway gates were closed.

August eventually saw a return to more normal precipitation over both the North and South Saskatchewan River basins and releases from both Lake Diefenbaker and Tobin Lake returned to normal.

C. FLOOD CONTROL

In 1981, the flood control benefit was of some significance in the operation of Lake Diefenbaker and Tobin Lake. On the South Saskatchewan River below Lake Diefenbaker the maximum daily flow without regulation would have been in the order of 1 800 m^3/s. The recorded maximum was 725 m^3/s; approximately 40 per cent of the estimated unregulated peak. On the Saskatchewan River below Tobin Lake the unregulated flow would have been in the order of 2 290 m^3/s, rather than the recorded maximum of 1 490 m^3/s or 65 per cent of the estimated unregulated peak flows. Figures 17 and 18 show the flow patterns that occurred below the two reservoirs as compared to what would have occurred without regulation.

D. CRITICAL EVENTS AND DECISIONS

The following is a list of events and decisions which took place in the May to August, 1981, period and which affected operations of the Saskatchewan River system:

- May 4, general rain started to fall in the southern half of Alberta with intensity increasing on May 5 and 6.

- May 7, the South Saskatchewan Reservoir Board met. The Board concluded Lake Diefenbaker was at a record high elevation (551.54 m) for this time of year due in part to the high January through March inflows which resulted from mild weather conditions, however, the best estimate for summer inflow to Lake Diefenbaker was 70 per cent of normal. To obtain a full reservoir elevation of 556.87 m would require reducing outflows to 45 m^3/s for a five month period. Outflows of 45 m^3/s were agreed upon.

- Week ending May 11 saw much of the headwaters of the North and South Saskatchewan Rivers in Alberta receive 30 to 150 mm of rain (Figure 13).

- May 14 and 16 - Generally the South Saskatchewan River basin in Alberta received 20 to 200 mm of rain with the most coming in the headwaters.

- Week ending May 18 saw much of the South Saskatchewan River basin in Alberta receive 30 mm to 200 mm of rain (Figure 14).

- May 19, ice had gone off Tobin Lake May 16, therefore, Saskatchewan Environment requested that SPC hold Tobin Lake at 313.30 m for fish spawning.

- May 22, SPC was reqested to increase flows from Coteau Creek to 60 m^3/s on May 23 and 75 m^3/s on May 24.

- Week ending May 25 saw the Oldman and St. Mary River Basins generally receive 40 mm to 80 mm of rain.

- May 25, the South Saskatchewan Reservoir Board met. Inflow to Lake Diefenbaker was at 1 000 m^3/s, the level of Lake Diefenbaker was 553.12 m and the inflow was projected to be at 2 150 m^3/s by May 28 (actual peak was 1 840 m^3/s on May 30). The decision was to run the powerhouse to capacity (400 m^3/s) with no spilling.

- SPC was advised to increase Squaw Rapids releases to 600 m^3/s on May 26.

- May 26, the South Saskatchewan Reservoir Board met. The level of Lake Diefenbaker was 553.31 m. Rate of rise on Lake Diefenbaker approaching that experienced in 1972 was discussed. Peak inflow was forecast to be reduced modestly, but with total volume increased. It was expected that spilling from Tobin Lake would be required by June 1 (spilling did not start at this time). It was estimated that 45 per cent to 80 per cent of the fish spawn had hatched in Tobin

Lake prior to the reservoir being lowered in preparation for the large inflows. PFRA was requested to start spilling 200 m^3/s from Lake Diefenbaker on May 27.

SPC was advised to start running Squaw Rapids at 900 m^3/s on May 27.

- May 27, the South Saskatchewan Reservoir Board met. The level of Lake Diefenbaker was 553.50 m. There was discussion of exceeding the rate of rise guidelines for Lake Diefenbaker. The board decided to continue with power plant capacity (400 m^3/s) plus 200 m^3/s spilling.

- May 28, the South Saskatchewan Reservoir Board met. There was discussion regarding the likelihood of another flood occurring during the summer. They decided to continue with the 600 m^3/s rate of release from Gardiner Dam.

- Week ending June 1 rain in the range of 20 mm to 40 mm had occurred in some areas scattered throughout the southern half of Alberta.

- June 1, the South Saskatchewan Reservoir Board met. The level of Lake Diefenbaker was 554.53 m. The Board discussed rate of rise at Lake Diefenbaker and decided to continue with the same releases.

- June 3, the South Saskatchewan Reservoir Board met. Inflow to Lake Diefenbaker was 1400 m^3/s and the lake level was 554.83 m. It was

decided to reduce the spill from Lake Diefenbaker from 200 m^3/s to 100 m^3/s.

- June 4, PFRA closed spillway gates at Gardiner Dam.

- June 8 to June 14 saw precipitation in the South Saskatchewan River basin in Alberta ranging from 25 mm to 150 mm with some falling as snow (Figure 15).

- June 14, PFRA was requested to begin discharging 200 m^3/s through the spillway at Gardiner Dam.

- June 15, the South Saskatchewan Reservoir Board met. It was estimated that there would be a peak of 1 400 m^3/s inflow to Lake Diefenbaker on June 20 (actual peak was about 1 025 m^3/s on June 18). The decision was made to continue with power plant capacity plus spilling 200 m^3/s from Lake Diefenbaker.

- June 17, the South Saskatchewan Reservoir Board met. Estimates of peak flows were reduced because of cool weather. It was decided to continue power plant capacity plus spilling 200 m^3/s from Lake Diefenbaker. It was also noted that no spills would have to be made from Tobin Lake.

- Week ending June 22 had rain in the range of 10 mm to 30 mm in southern Alberta.

- June 23, the South Saskatchewan Reservoir Board met. Estimates of flows into Lake Diefenbaker dropping to 600 m^3/s by June 28 were made (actual flows on June 28 were near 500 m^3/s). Discussion regarding inconvenience to downstream users was debated. It was noted that Lake Diefenbaker was at a record high level (556.23 m) for June 23. The Board decided to continue with 200 m^3/s spill from Lake Diefenbaker.

- June 26, the South Saskatchewan Reservoir Board met. It was decided to stop spilling from Lake Diefenbaker and that powerhouse releases could be between 300 m^3/s and 400 m^3/s mean daily.

  Tobin Lake minimum release should be 400 m^3/s.

- July 2, SPC was requested to have a minimum daily flow of 250 m^3/s, a maximum daily flow of 400 m^3/s with an average of 300-350 m^3/s over a five to seven day period at Lake Diefenbaker.

  Releases at Tobin Lake should be no less than 250 m^3/s.

- The week ending July 13 saw 5 mm to 25 mm of rain fall over most of the southern half of Alberta.

- July 15, because of more rain in Alberta SPC was requested to release power plant capacity (400 m^3/s) from Lake Diefenbaker and average 500 m^3/s from Tobin Lake.

- July 16, SPC was advised to increase releases from Tobin Lake to 700-800 m^3/s on week days and 600-700 m^3/s on weekends.

- July 17, SPC was requested to release 350 m^3/s from Lake Diefenbaker July 18 and 19 and 400 m^3/s on July 20.

- Week ending July 20 rainfall in the North and South Saskatchewan River basins of Alberta ranged around 10-80 mm.

- Week ending July 27, 1983, saw rain from 5 mm to 50 mm fall over the North and South Saskatchewan River basins.

- July 29, the South Saskatchewan Reservoir Board met. Lake Diefenbaker rate of rise, problems with exceeding FSL, and problems for users downstream receiving flows of over 850 m^3/s was discussed. The decision was to start spilling 50 m^3/s from Lake Diefenbaker.

- July 30, the South Saskatchewan Reservoir Board met. Red Deer River flows were forecast to be 850 m^3/s August 1 (flows reached 650 m^3/s August 4). Inflow to Lake Diefenbaker was forecast to be 1 150 m^3/s on August 4 (inflow reached 960 m^3/s August 6). The decision was to start spilling 200 m^3/s from Lake Diefenbaker July 30 and 330 m^3/s July 31.

- July 31, SPC was advised to begin spilling 500 m^3/s from Tobin Lake

which would make a total release of 1 300 m^3/s. Precipitation is indicated on Figure 16.

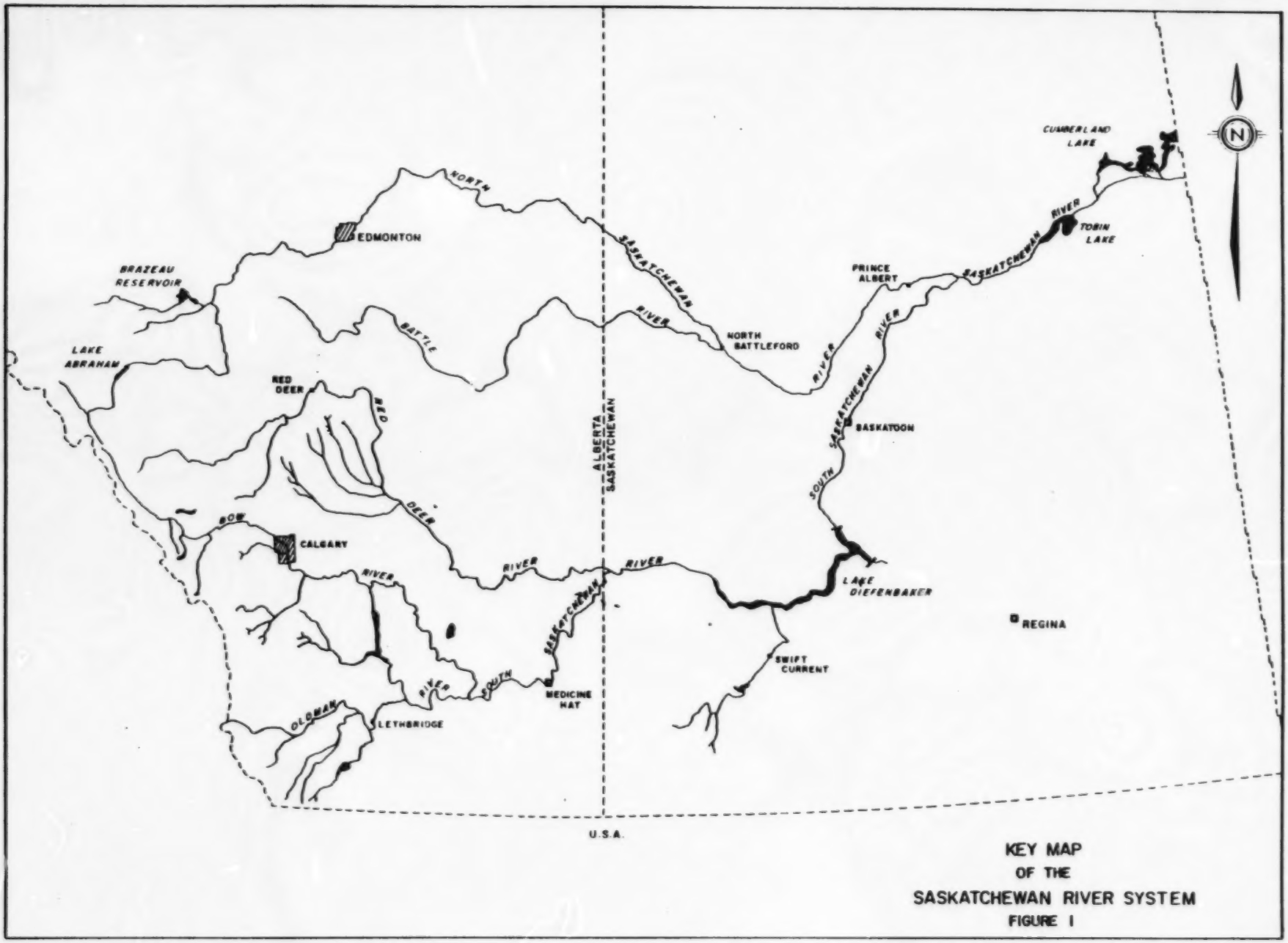
- August 10, PFRA stopped spilling from Lake Diefenbaker and SPC reduced spill from Tobin Lake to 300 m^3/s.

- August 12, SPC was advised to reduce spill from Tobin Lake to 150 m^3/s.

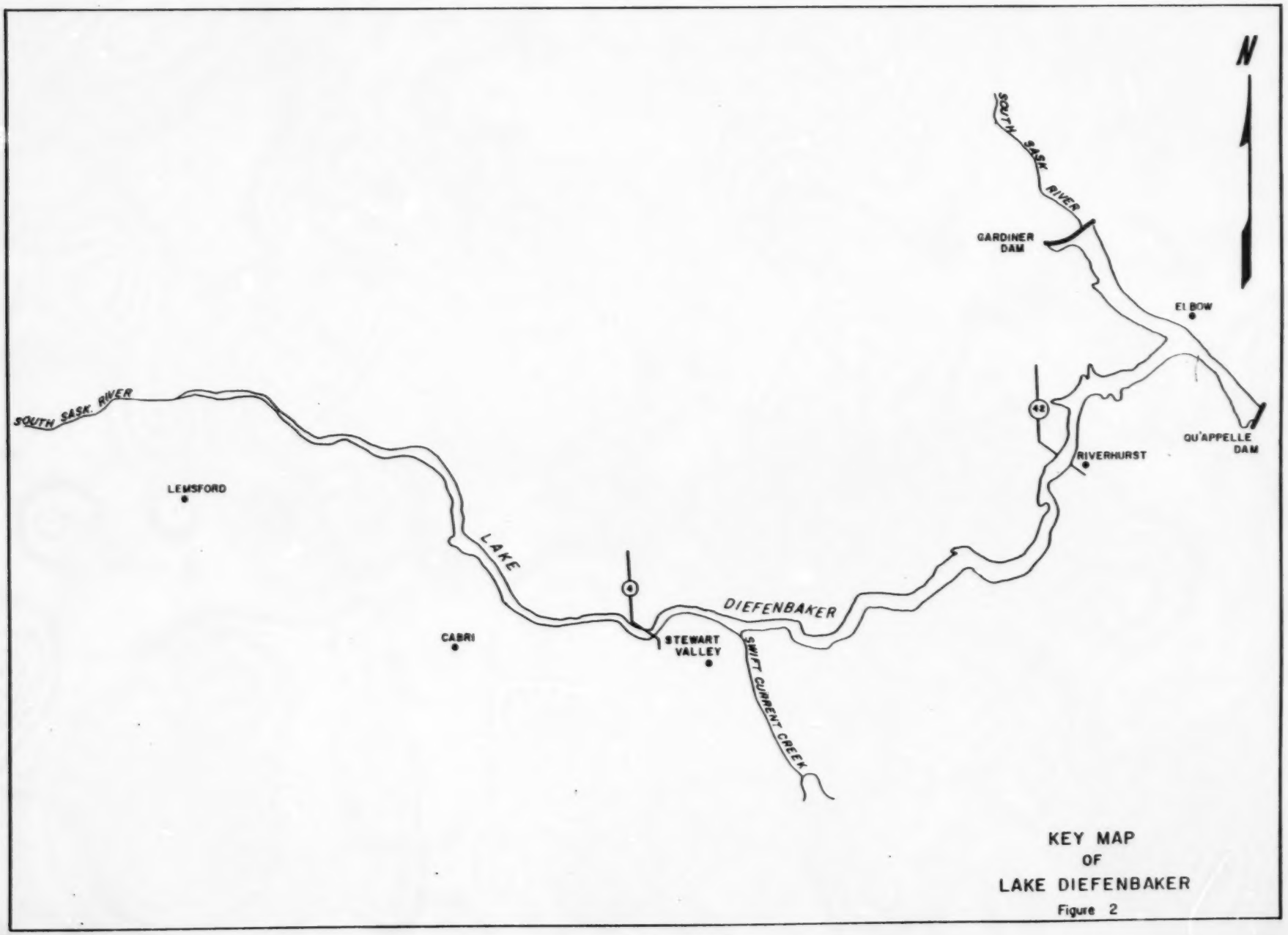
- August 14, SPC was advised to reduce spill from Tobin Lake to 100 m^3/s.

- August 15, SPC terminated spill from Tobin Lake.

FIGURES

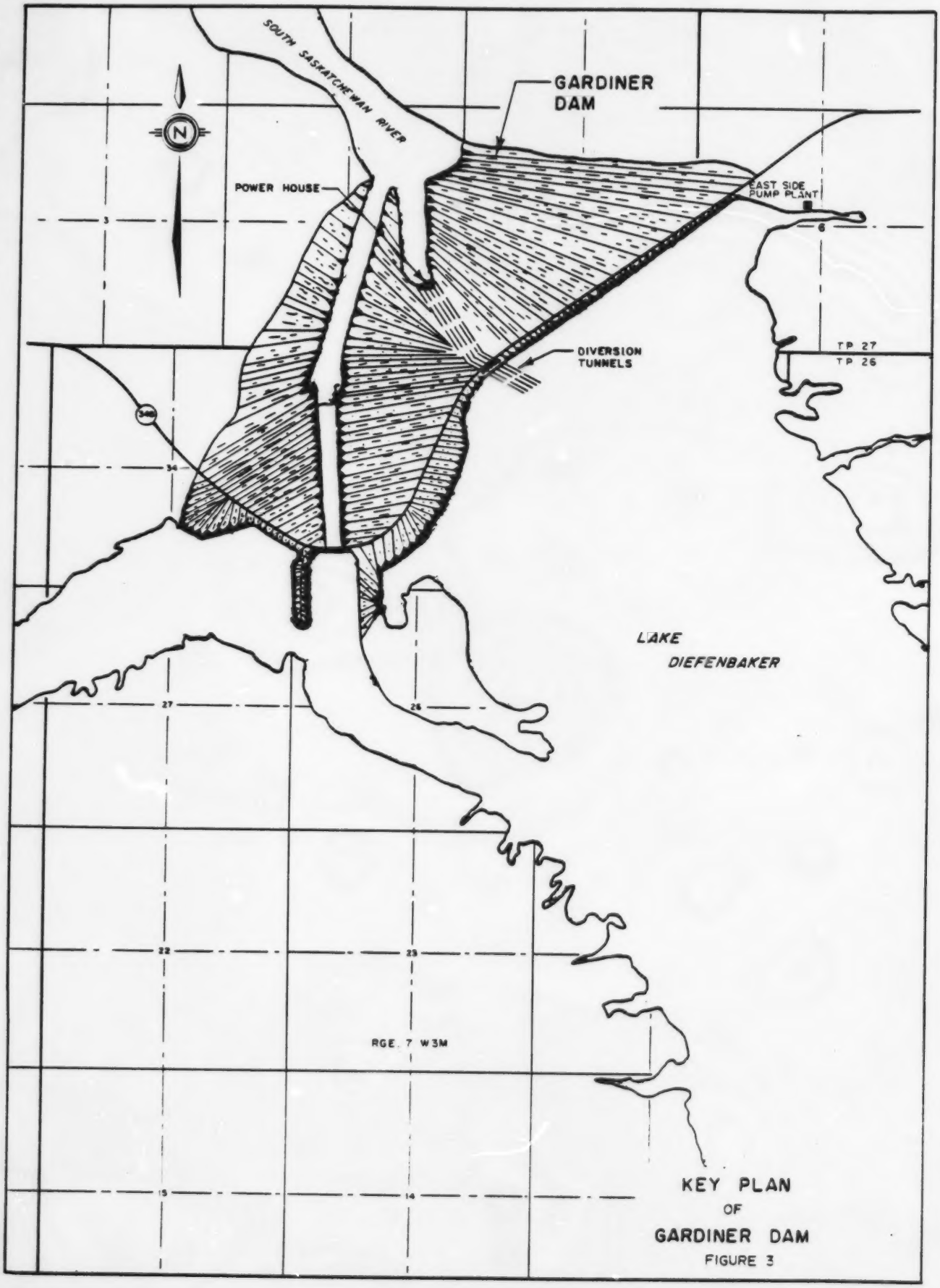


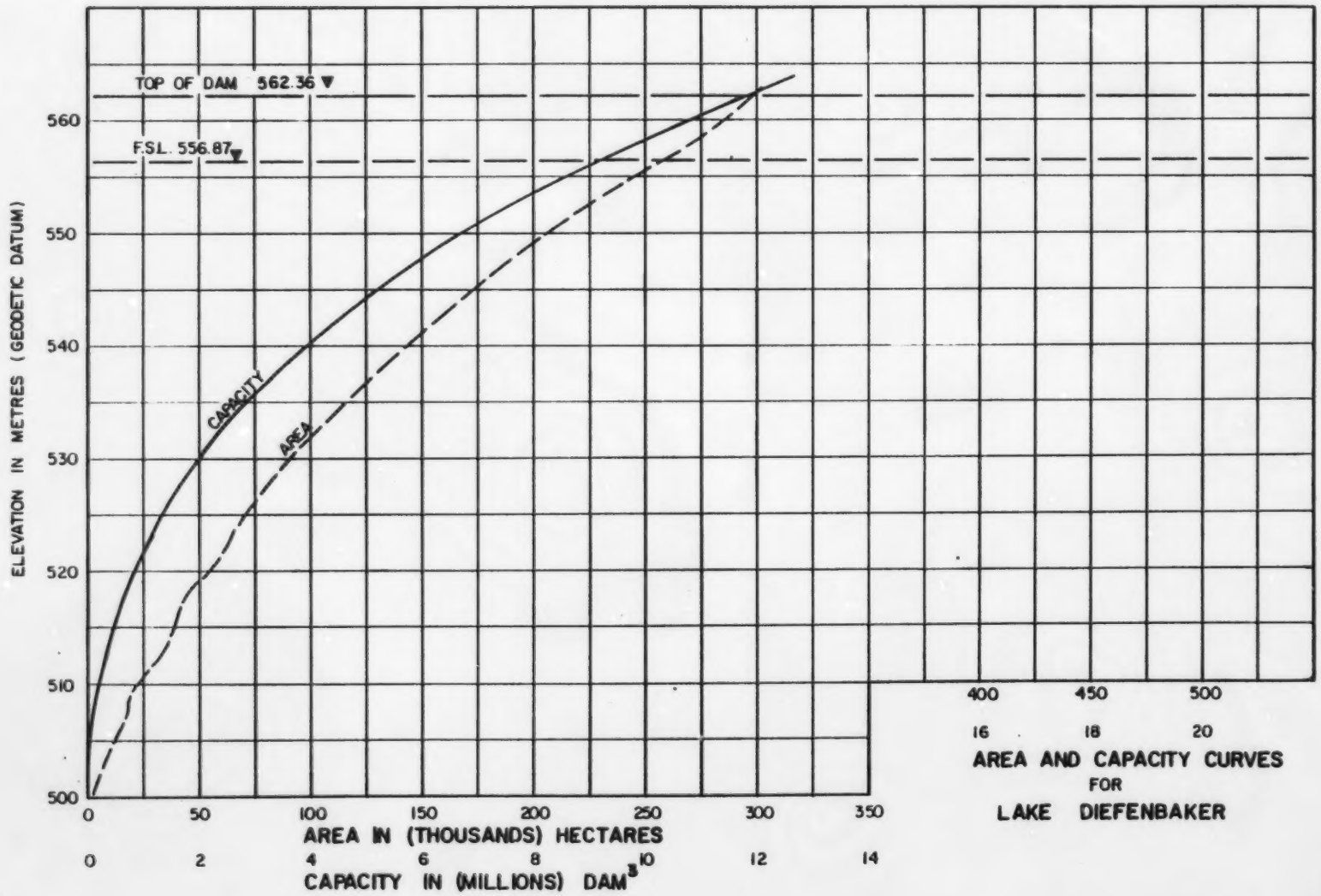
KEY MAP
OF THE
SASKATCHEWAN RIVER SYSTEM
FIGURE 1



KEY MAP
OF
LAKE DIEFENBAKER

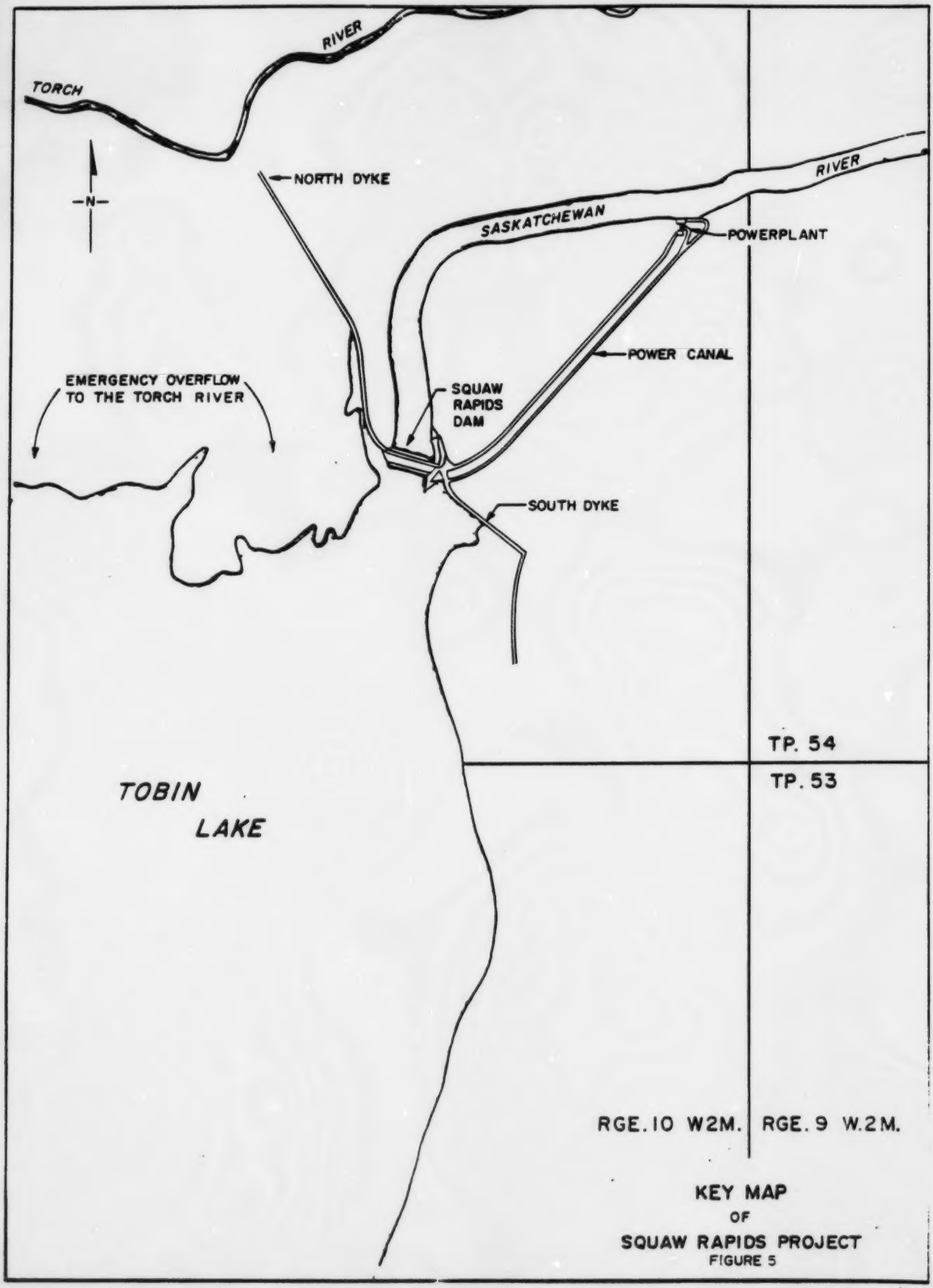
Figure 2


SOUTH SASKATCHEWAN RIVER
GARDINER DAM
POWER HOUSE
EAST SIDE PUMP PLANT
DIVERSION TUNNELS
TP 27
TP 26
LAKE DIEFENBAKER
RGE. 7 W3M
KEY PLAN
OF
GARDINER DAM
FIGURE 3

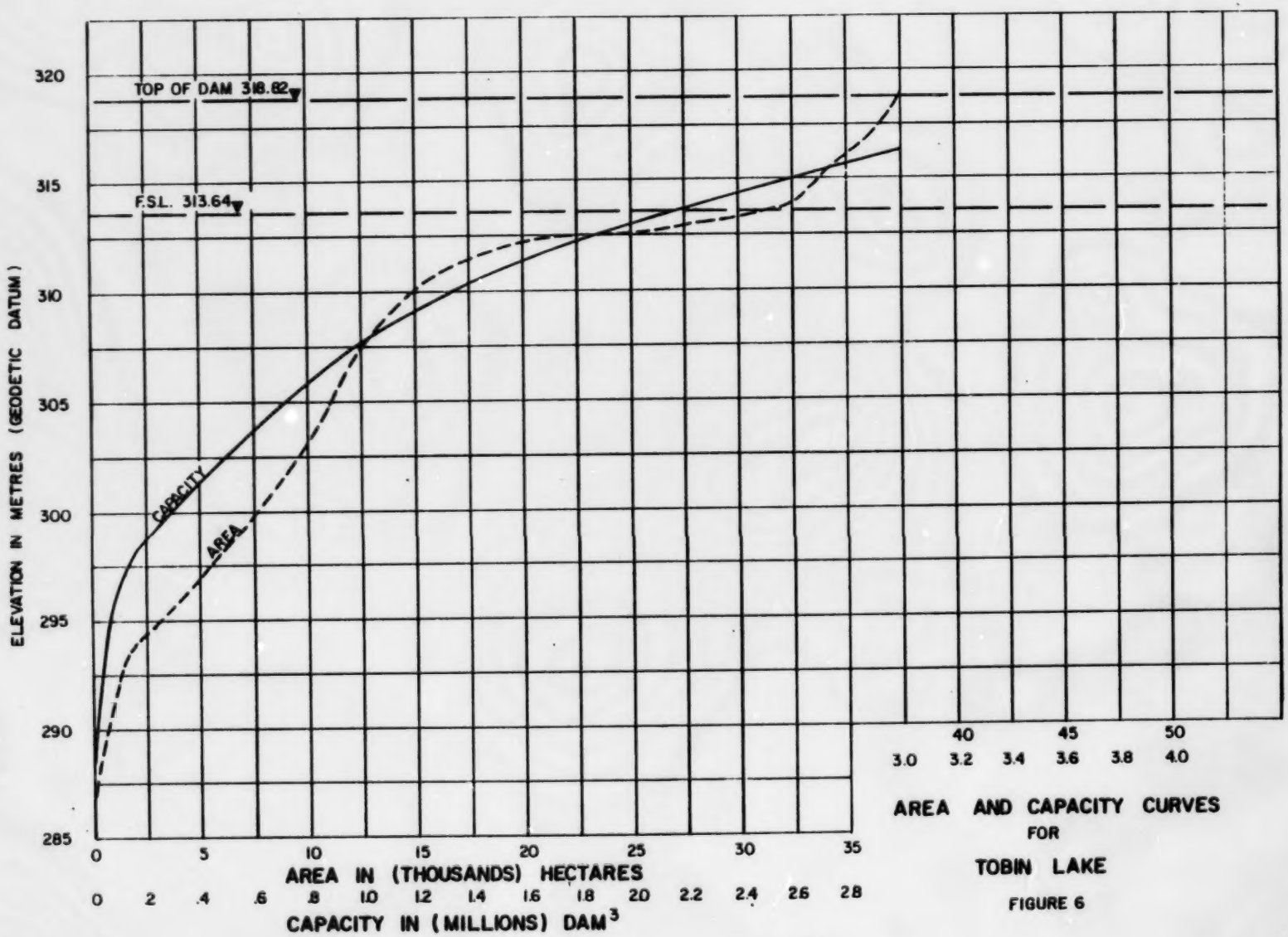


AREA AND CAPACITY CURVES
FOR
LAKE DIEFENBAKER

FIGURE 4

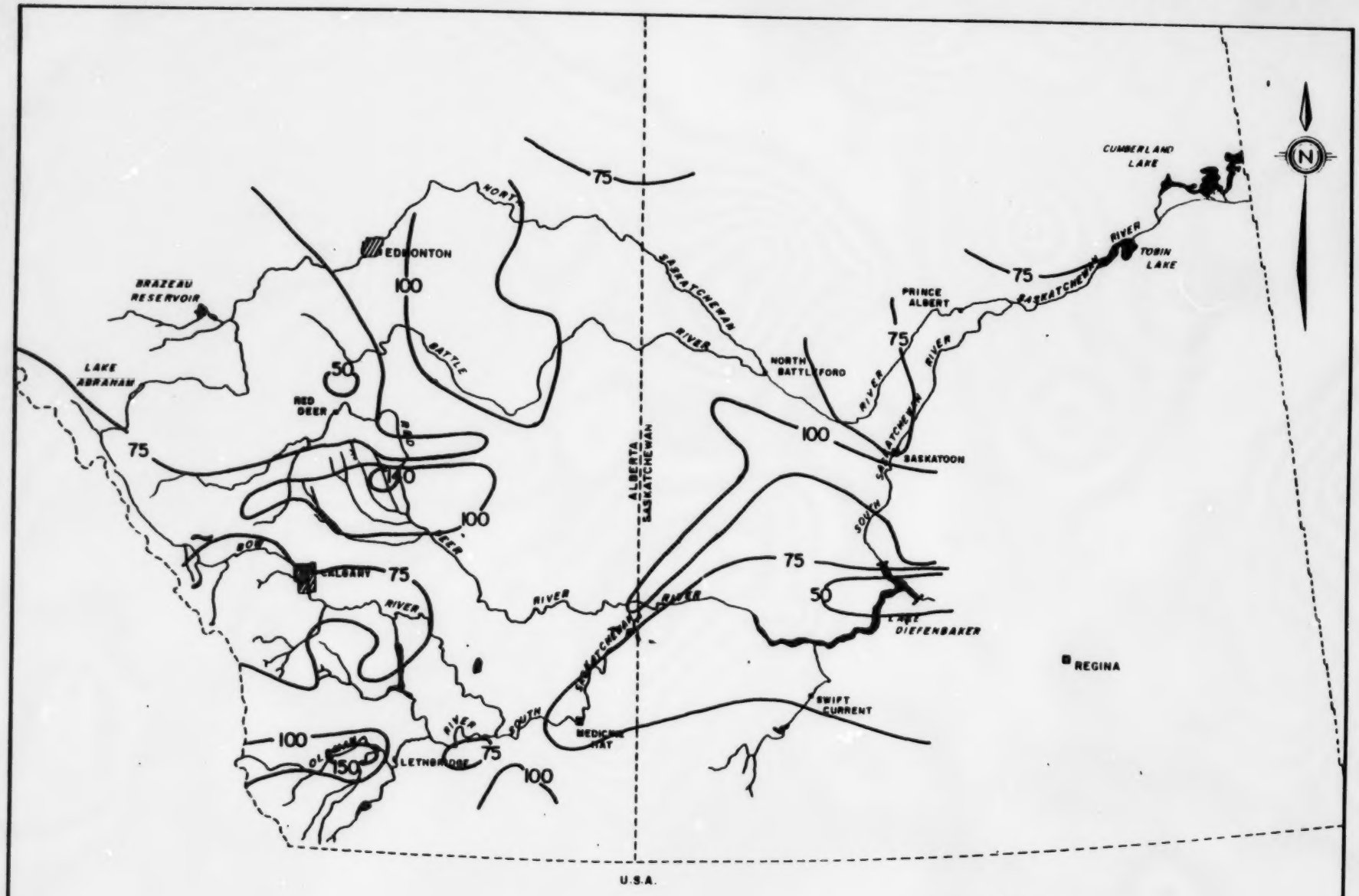


KEY MAP
OF
SQUAW RAPIDS PROJECT
FIGURE 5

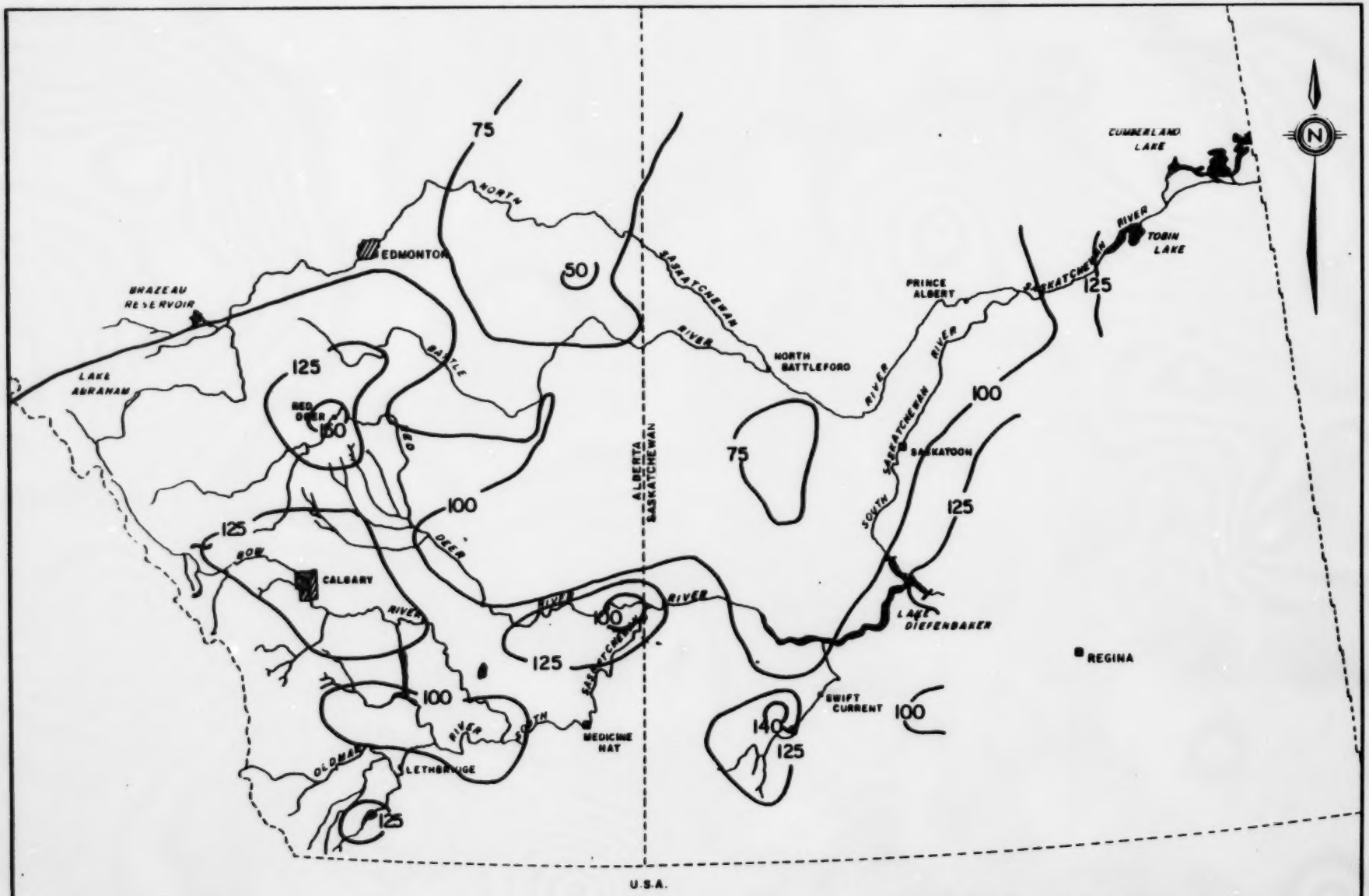


AREA AND CAPACITY CURVES
FOR
TOBIN LAKE

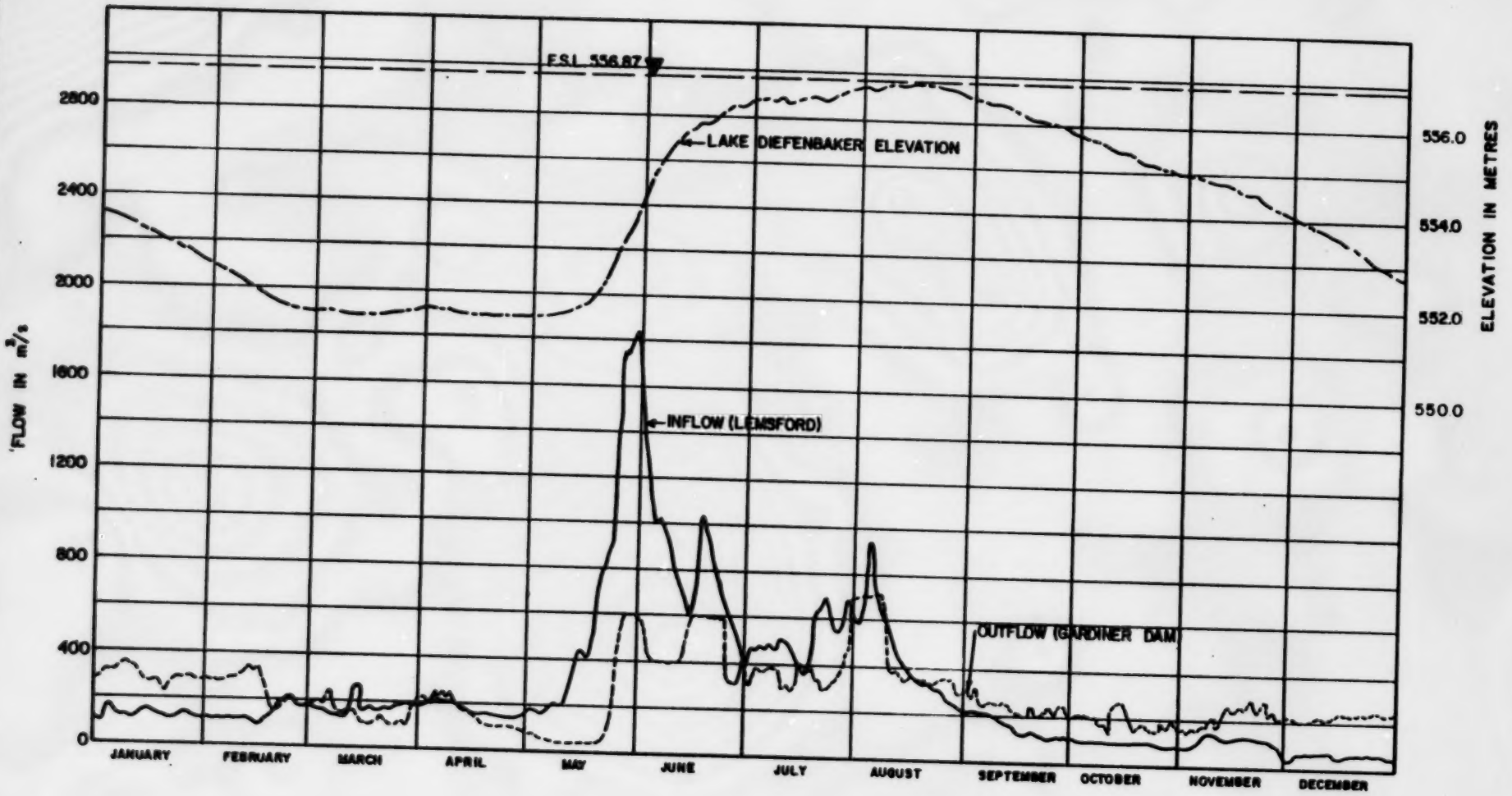
FIGURE 6



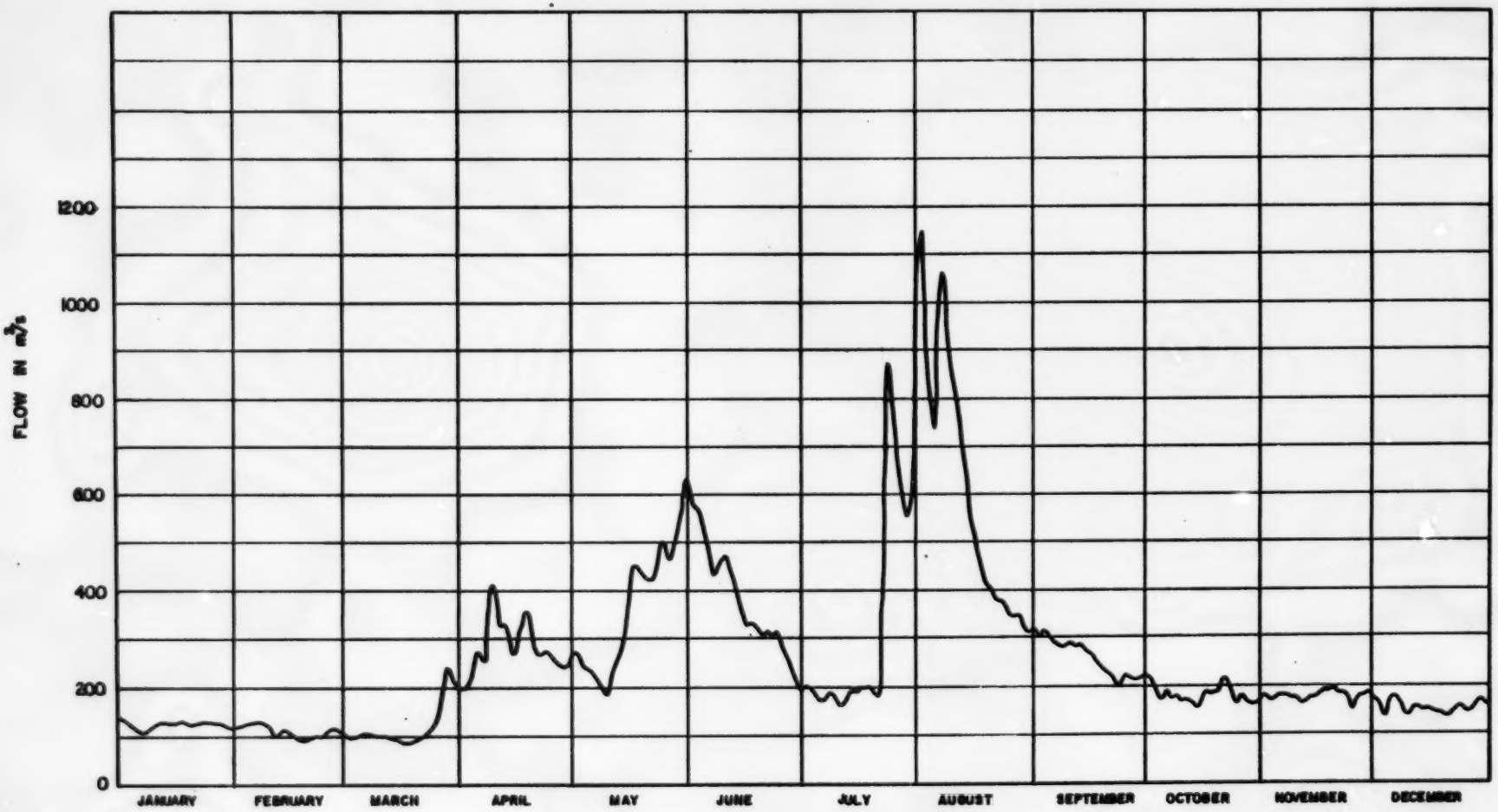
NOVEMBER 1980 TO APRIL 1981
PERCENT OF NORMAL PRECIPITATION
OVER THE SASKATCHEWAN RIVER SYSTEM
FIGURE 7



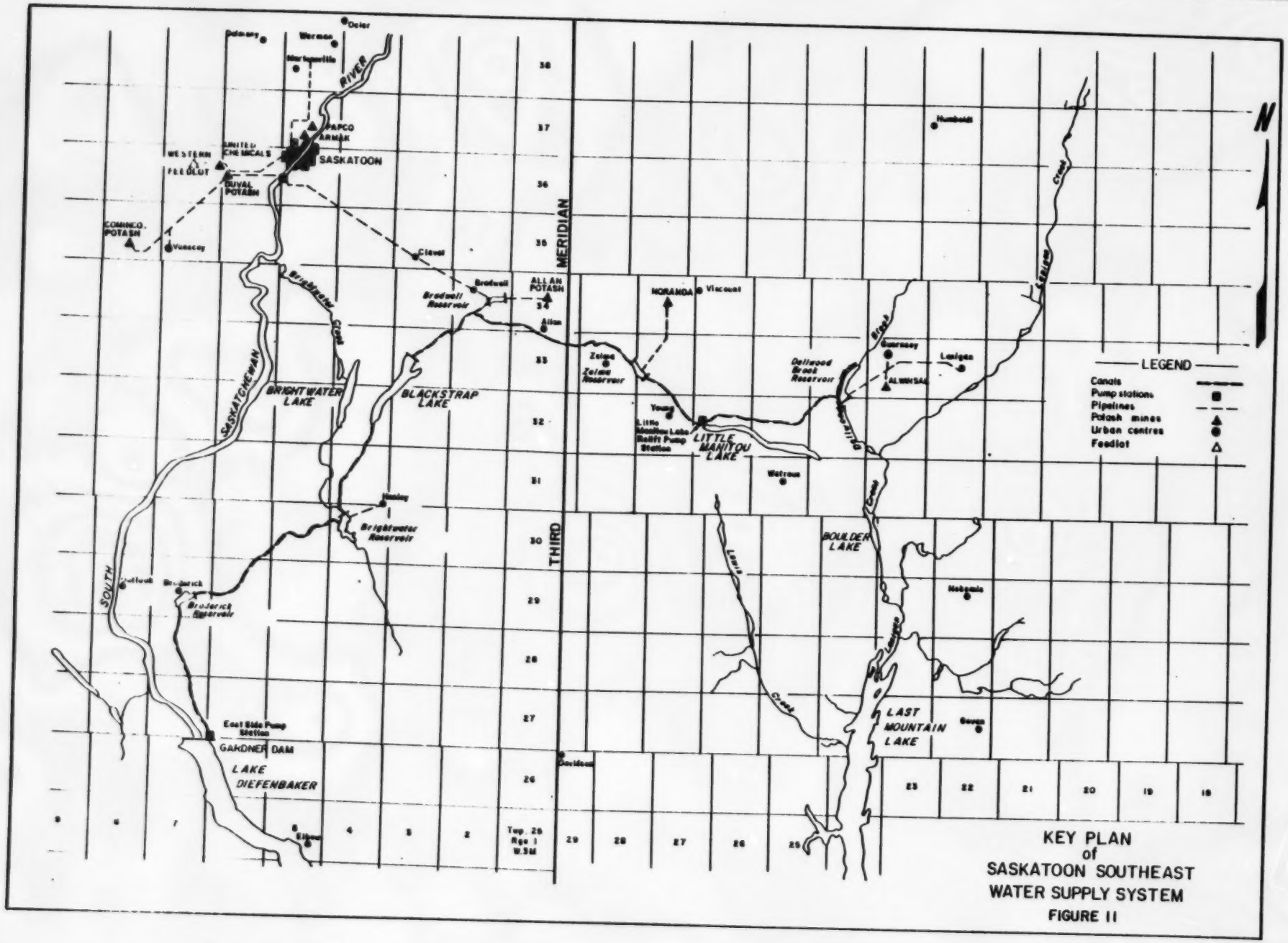
MAY TO OCTOBER 1981
PERCENT OF NORMAL PRECIPITATION
OVER THE SASKATCHEWAN RIVER SYSTEM
FIGURE 8



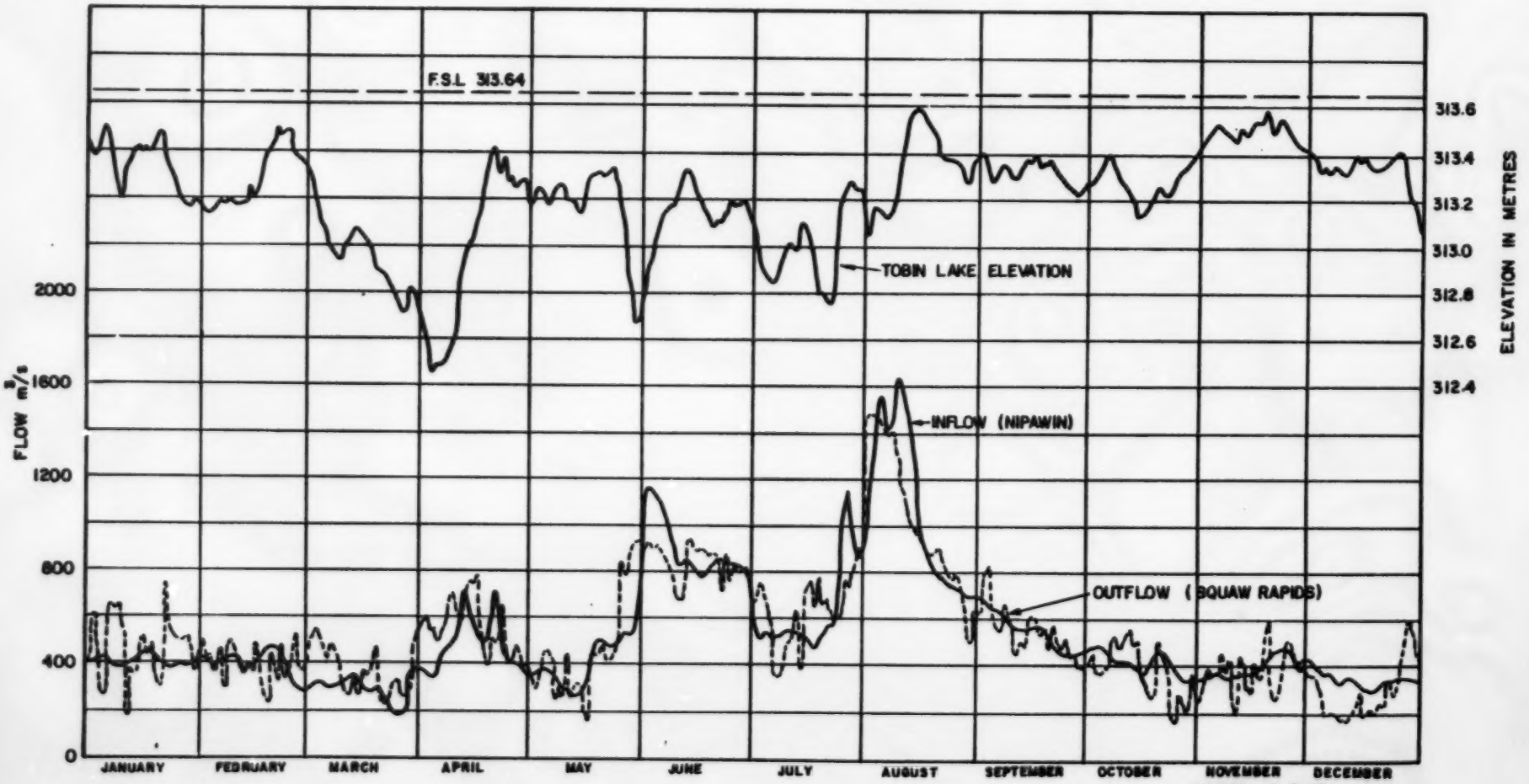
LAKE DIEFENBAKER
1981
INFLOW, OUTFLOW
AND
LAKE ELEVATION
FIGURE 9



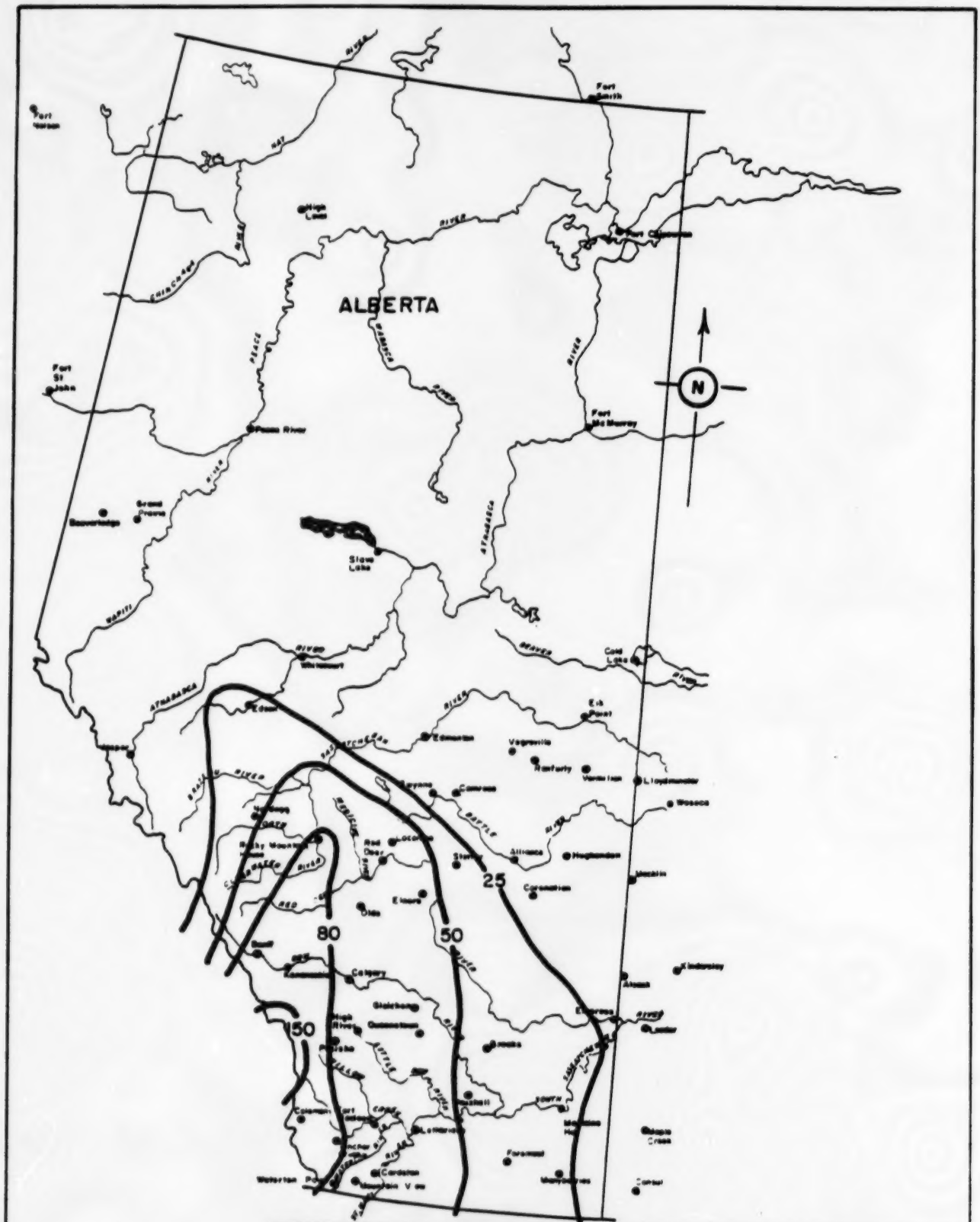
NORTH SASKATCHEWAN RIVER
1981
PRINCE ALBERT
HYDROGRAPH
FIGURE 10



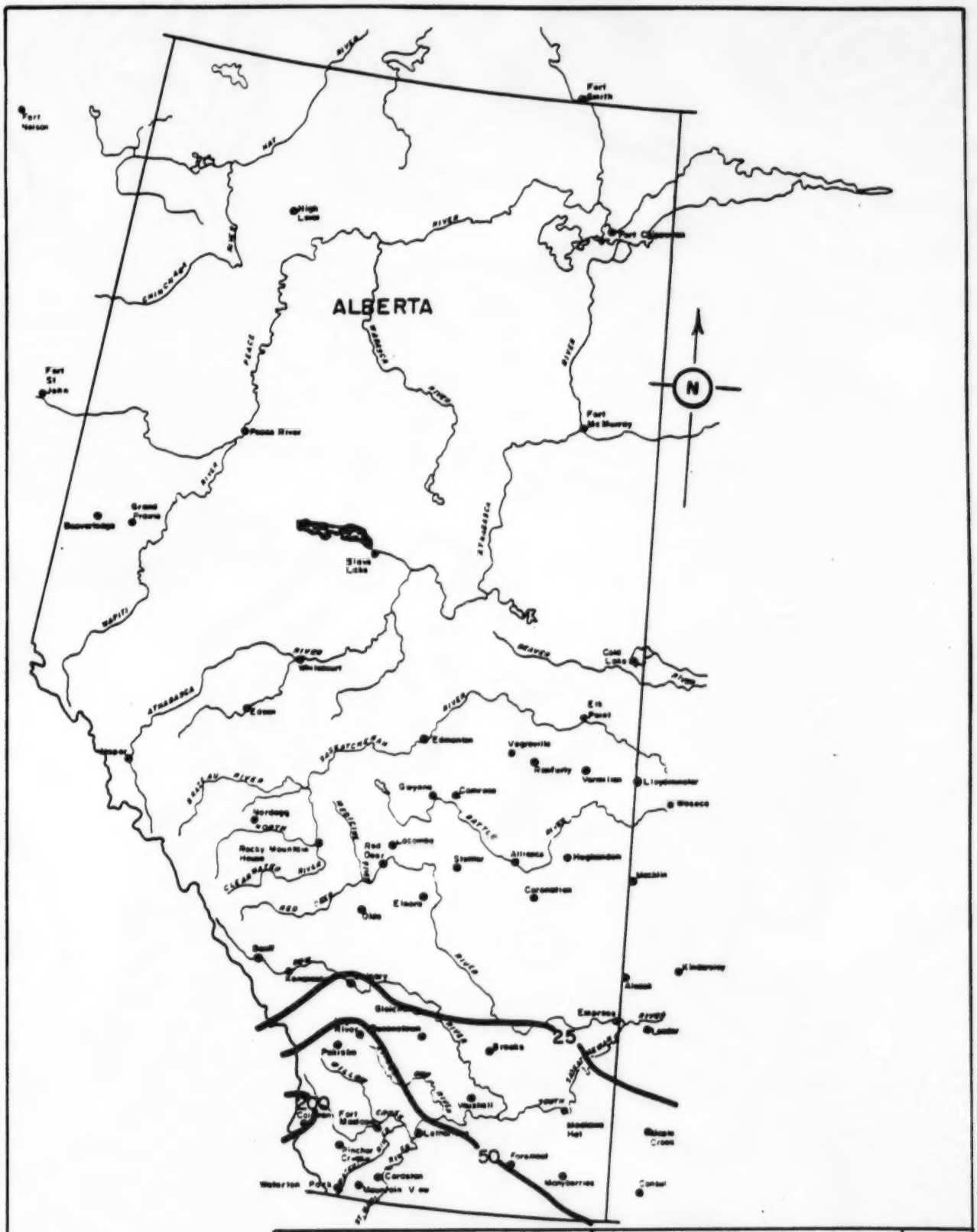
KEY PLAN
of
SASKATOON SOUTHEAST
WATER SUPPLY SYSTEM
FIGURE 11



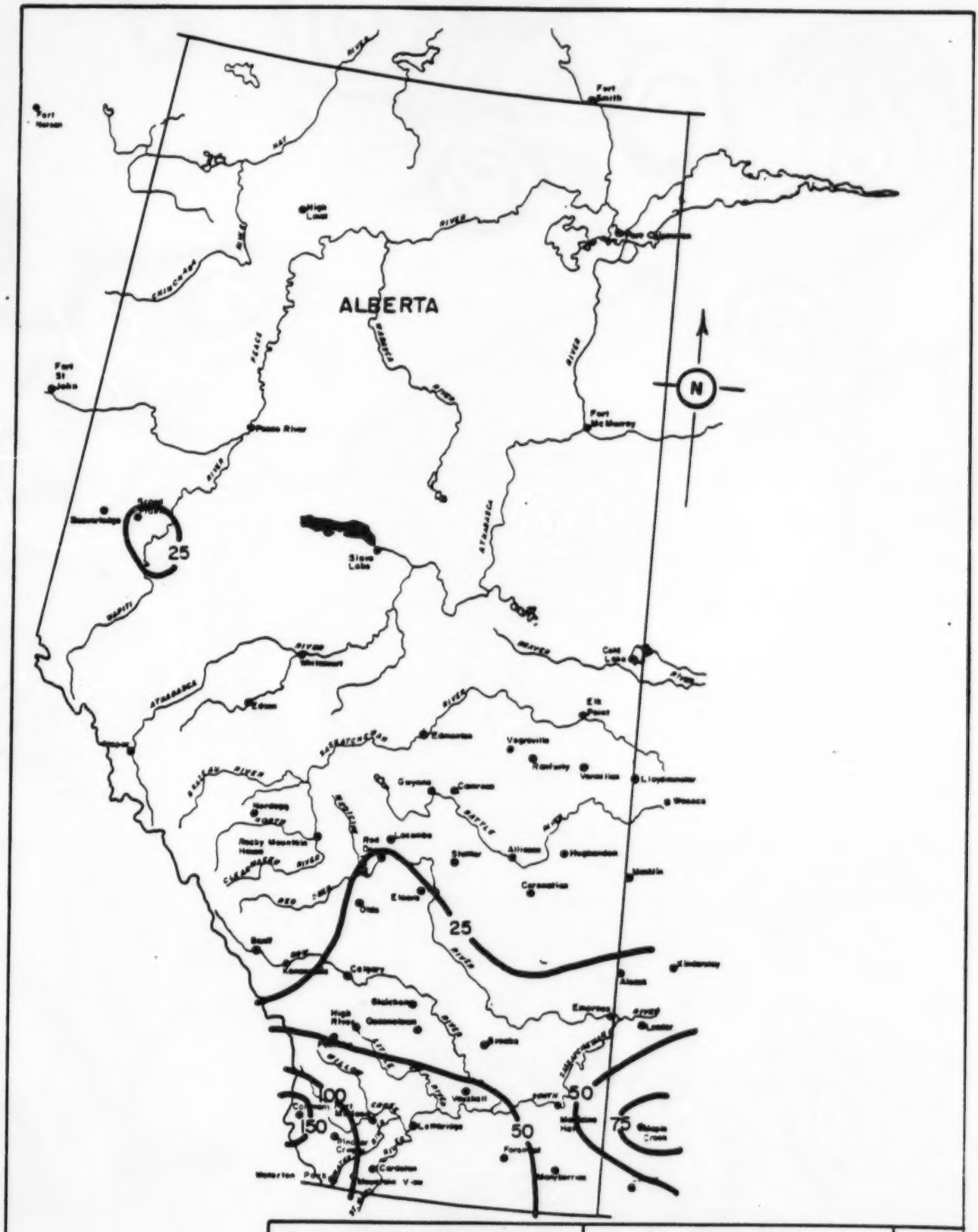
TOBIN LAKE
1981
INFLOW, OUTFLOW
AND
LAKE ELEVATION
FIGURE 12



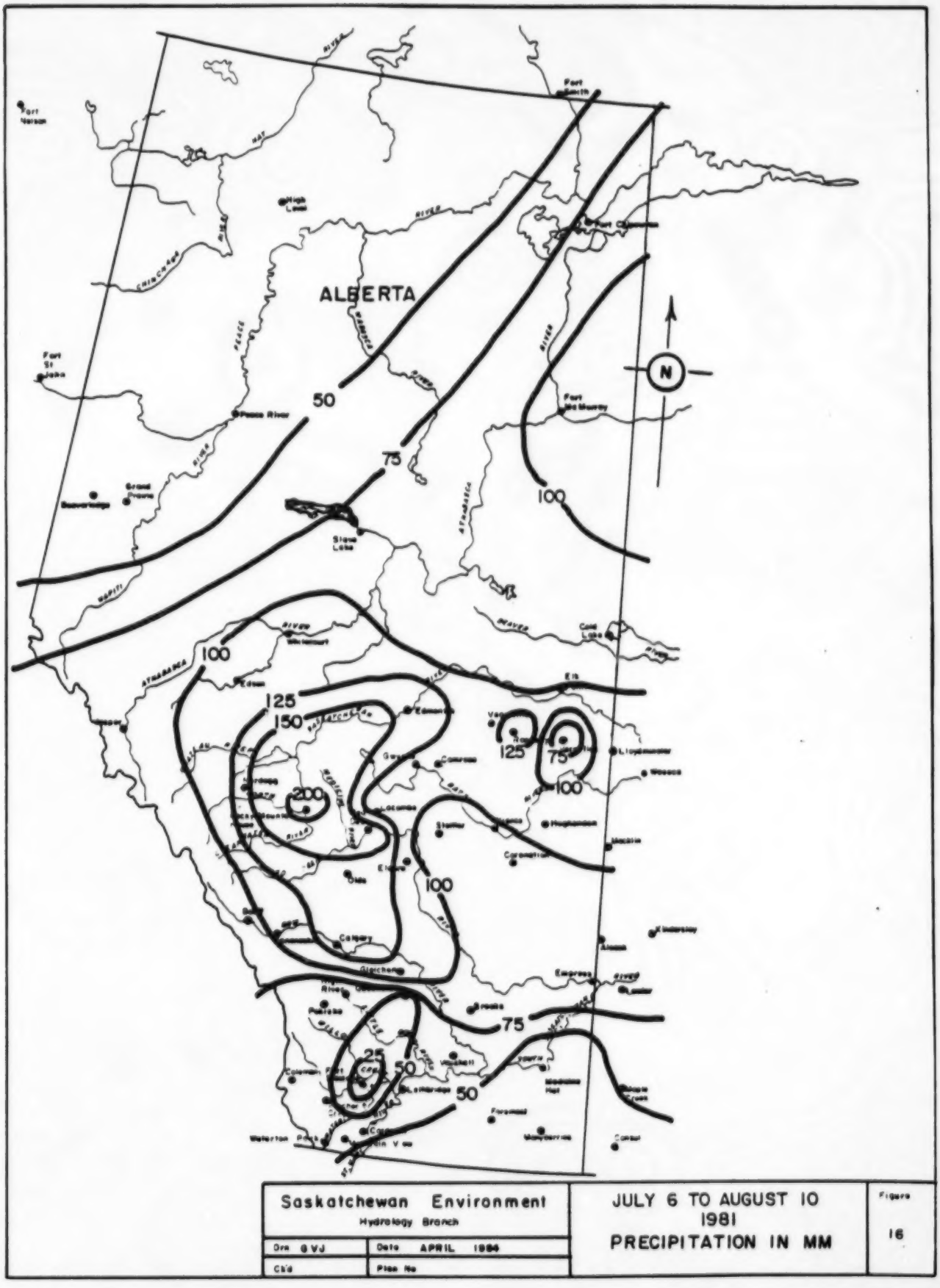
Saskatchewan Environment Hydrology Branch	MAY 4 TO 10 1981 PRECIPITATION IN MM	Figure 13
Drn B V J — Date APRIL 1984		
Ck'd — Plan No		



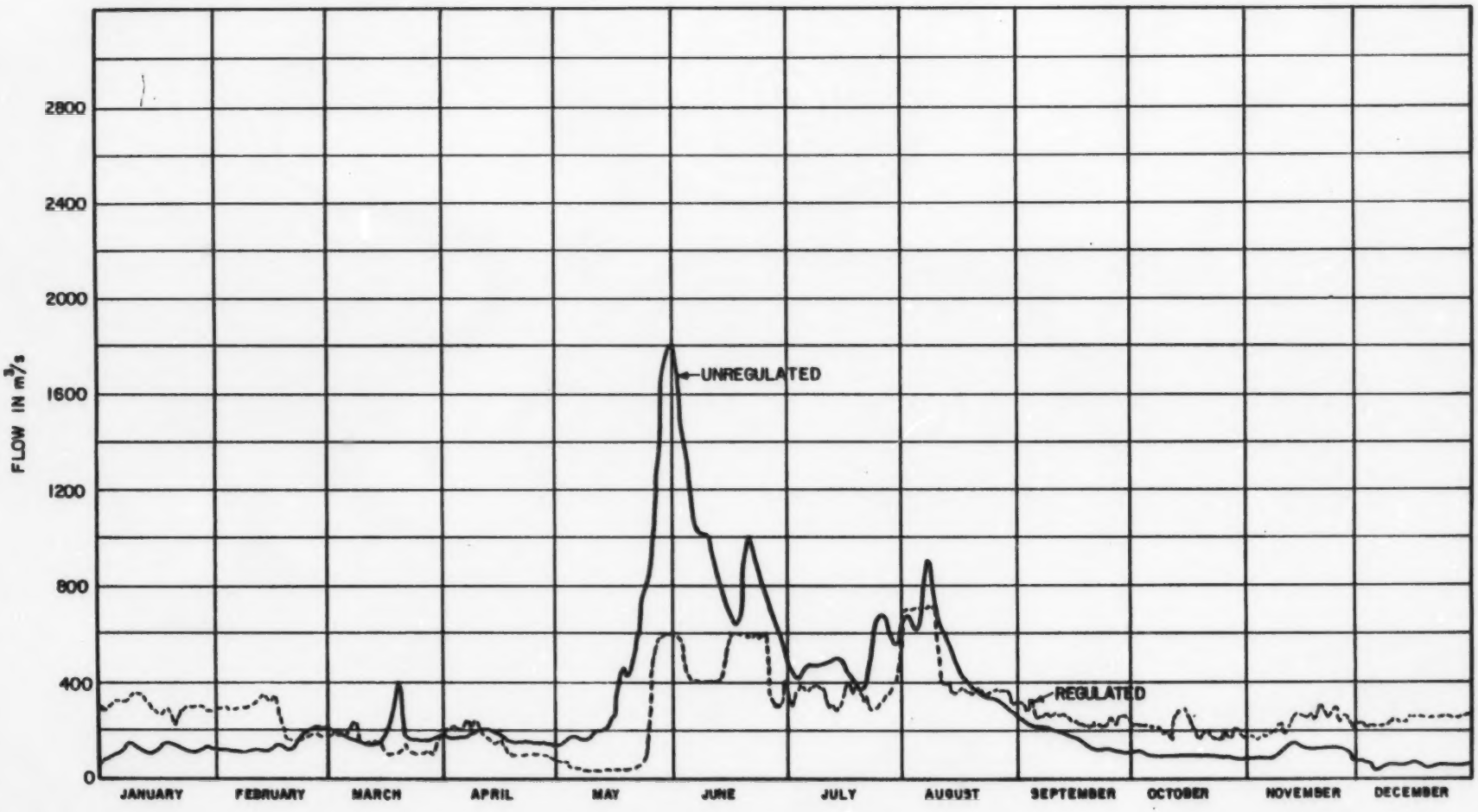
Saskatchewan Environment Hydrology Branch	MAY 11 TO 17 1981 PRECIPITATION IN MM	Figure 14
Drn BVJ / Date APRIL 1984		
Ckd / Plan No		



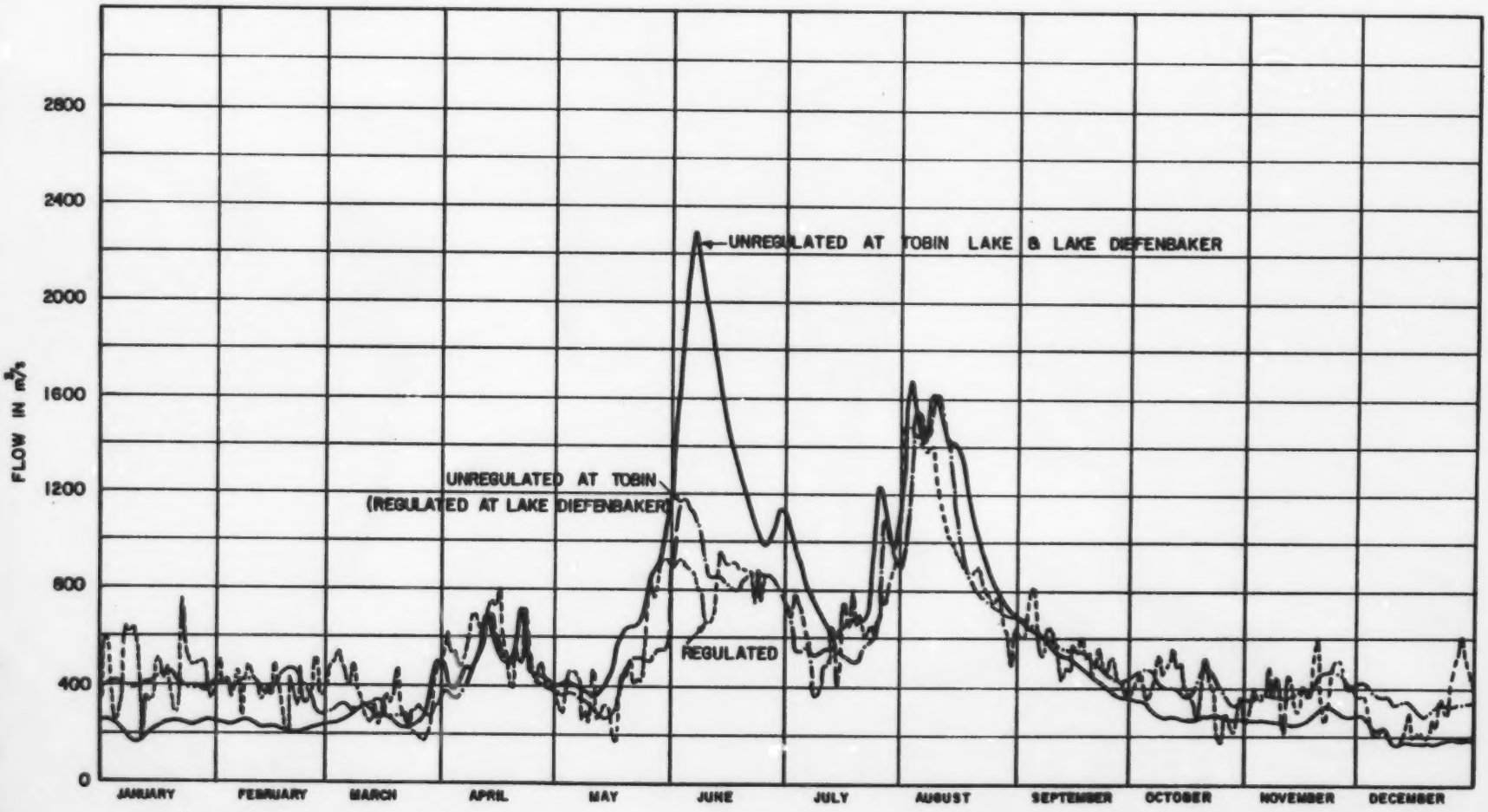
Saskatchewan Environment Hydrology Branch		JUNE 8 TO 14 1981 PRECIPITATION IN MM	Figure 15
Drn G V J	Date APRIL 1984		
Ck'd	Plan No		



Saskatchewan Environment Hydrology Branch		JULY 6 TO AUGUST 10 1981 PRECIPITATION IN MM
Drn G VJ	Date APRIL 1984	Figure 16
Ckd	Plan No	



EFFECT OF LAKE DIEFENBAKER REGULATION
DURING 1981
ON
SOUTH SASKATCHEWAN RIVER FLOWS
AT CUTBANK



EFFECT OF REGULATION
DURING 1981
AT LAKE DIEFENBAKER & TOBIN LAKE
ON FLOWS IN THE
SASKATCHEWAN RIVER BELOW SQUAW RAPIDS
FIGURE 18

APPENDIX A

HISTORICAL DEVELOPMENT AND OPERATING CRITERIA FOR THE SASKATCHEWAN RIVER SYSTEM

Table of Contents

		Page
A.	INTRODUCTION	A-1
B.	LAKE DIEFENBAKER DEVELOPMENT	A-1
C.	SQUAW RAPIDS DEVELOPMENT	A-3
D.	OPERATING GROUND RULES	A-5
	1. Lake Diefenbaker Levels	A-5
	2. Tobin Lake Levels	A-5
	3. Lake Diefenbaker Outflow to the Qu'Appelle River	A-6
	4. Lake Diefenbaker Releases to the South Saskatchewan River	A-6
E.	AGENCIES INVOLVED IN OPERATION	A-7

APPENDIX A

A. INTRODUCTION

The Saskatchewan River system in Saskatchewan is free flowing except for two major reservoirs, Lake Diefenbaker and Tobin Lake. This text is a documentation of the system's development to date and operating criteria. Figure 1 shows a key map of the system.[1/]

B. LAKE DIEFENBAKER DEVELOPMENT

In the period from 1958 to 1967, Canada, through PFRA, and Saskatchewan jointly constructed the Gardiner and Qu'Appelle Dams, creating Lake Diefenbaker. Figure 2 shows the two dams and Lake Diefenbaker.

The cost of the South Saskatchewan project was about $120 000 000. Under a cost-sharing agreement, Saskatchewan financed $25 000 000 and Canada financed the remaining $95 000 000. Canada supervised construction of the works and provided all engineering.

The total cost included $42 000 000 for embankment construction at Gardiner Dam, $37 000 000 for diversion tunnels, $18 000 000 for the spillway, $10 000 000 for the Qu'Appelle River Dam, $3 000 000 for land purchase and clearing and $10 000 000 for access roads, rail relocation, town site and other miscellaneous items. Figure 3 shows the general layout of Gardiner Dam.

1/ All figures referred to in this appendix are contained in the main body of the report.

The cost of the Coteau Creek generating station at Gardiner Dam was not shared and represents an investment by Saskatchewan through the Saskatchewan Power Corporation of about $40 000 000.

Saskatchewan has also invested in works to utilize the water of Lake Diefenbaker for irrigation and for municipal and industrial water supply through the east side pump plant: for the Saskatoon-Southeast Water Supply system, and improvements to the Qu'Appelle River. The consumptive uses of water from Lake Diefenbaker are very important, but in total they utilize only a small fraction of the total flow of the South Saskatchewan River.

Between 1965 and 1969, as construction neared completion, part of the flow of the South Saskatchewan River was stored and the reservoir was slowly filled. A lake was created that covers about 262 000 hectares and contains 9.4 million dam^3 of water. About 188 000 hectares are permanently flooded by about 5.4 million dam^3 of permanent storage, while the remaining 3.9 million dam^3 of volume are available for flow regulation. Curves showing the storage volume and surface area versus elevation are shown on Figure 4.

During the period of filling, flow in the South Saskatchewan River was maintained by releasing water through the diversion tunnels. From September, 1968, these releases were used for power generation at Coteau Creek Generating Station. The three diversion tunnels that have been harnessed for power generation can handle releases of up to 425 cubic metres per second (m^3/s) and can generate 187 500 kilowatts

at peak capacity. When necessary, outflows in excess of the power plant capacity are released through the gated spillway.

Besides the power production, irrigation, municipal and industrial water supply and the Qu'Appelle River water supply benefits, Lake Diefenbaker has become an important recreation center and sport fishing area. The large lake also provides flood control and with careful planning and integrated operation it has greatly increased the economic value of the Squaw Rapids Generating Station.

C. SQUAW RAPIDS DEVELOPMENT

The Squaw Rapids development was completed by the Saskatchewan Power Corporation on the Saskatchewan River a short distance downstream of Nipawin in 1964. Figure 5 shows the general configuration of the development.

This project receives the combined flow of the North and South Saskatchewan Rivers. The reservoir, Tobin Lake, covers 185 000 hectares and has a usable storage capacity of 623 000 dam^3. Considering that the volume of the water flowing at this location is about twice that received at Lake Diefenbaker and the reservoir is substantially smaller, there is a much smaller effect on the seasonal flow patterns caused by this project than by Lake Diefenbaker. This power development is operated as essentially a "run of the river" operation with the storage capacity used to provide short-term flexibility. Use of this storage is planned on a week-to-week or at

most a month-to-month basis rather than on a seasonal or annual basis as at Lake Diefenbaker. Area and storage capacity curves are shown on Figure 6 for Tobin Lake.

Squaw Rapids has eight generating units that can pass up to 1 133 m^3/s and produce 281 000 kilowatts at peak capacity. The spillway is used to pass flows in excess of 1 133 m^3/s when necessary.

Regulated flows on the South Saskatchewan River as a result of Lake Diefenbaker greatly enhance the economic importance of Squaw Rapids Generating Station for power generation. Since water that is used at Coteau Creek Generating Station flows to Squaw Rapids, it is available for a second use a few days after leaving Lake Diefenbaker. Planning of operation at Coteau Creek must, therefore, take into account this second use and operations of the two generating stations must be closely co-ordinated.

Two power reservoirs in Alberta, Brazeau Reservoir and Lake Abraham, have improved flow patterns of the North Saskatchewan River for power generation in Saskatchewan. Brazeau Reservoir was first operated in 1961 and the Big Horn Dam forming Lake Abraham was completed in 1972. These Alberta reservoirs control only a portion of the headwaters of the North Saskatchewan River, but they have greatly increased the winter flows and thereby added to the usefulness of Squaw Rapids for meeting peak winter power demands.

Although it was built as a reservoir for a hydroelectric generating station, Tobin Lake has developed into a recreation area and also provides some flood control to the Cumberland Lake area and areas downstream in Manitoba.

D. OPERATING GROUND RULES

Criteria for operation of the Saskatchewan River system have been developed. These criteria provide general guidelines for operation, but they leave ample flexibility to accommodate changing conditions.

1. Lake Diefenbaker Levels

Lake Diefenbaker was constructed to accommodate surface water elevations as low as 545.6 metres and as high as 556.8 metres. Water levels cannot be lowered below 545.6 metres because the dams are only protected by riprap down to 545 metres and lower water levels could undermine this slope protection and damage the dams. Elevation 556.8 metres is the upper limit of normal operation and provides adequate freeboard for the safety of the dams.

In order to accommodate recreation use of the lake, it has generally been accepted that elevations in excess of 555.3 metres should be maintained through July and August (whenever the water supply is adequate).

2. Tobin Lake Levels

The upper operating level is 313.6 metres; if this level is exceeded by more than 0.3 m water spills north out of the

reservoir into the Torch River. The normal lower operating limit is 311.5 metres because the channel that carries water to the power plant begins to lose flow capacity if lower levels occur.

3. Lake Diefenbaker Outflow to the Qu'Appelle River

The Qu'Appelle River Dam conduit can release a maximum of 74 m^3/s at full capacity, however, the Qu'Appelle River can only carry 11 m^3/s and therefore this has been the limit on releases from the Qu'Appelle River Dam.

4. Lake Diefenbaker Releases to the South Saskatchewan River

Releases at Gardiner Dam take two forms. Most of the releases are made through the hydroelectric turbines at the Coteau Creek Generating Station which can release up to 425 m^3/s. When releases greater than 425 m^3/s are necessary, the spillway gates have to be opened.

During planning and construction of the South Saskatchewan River project, intensive studies were carried out to determine downstream flow requirements. It was found that all the water intakes for water supply could be modified to accommodate flows as low as 42.5 m^3/s without major expenditures and that the ferry crossings could also be modified to permit operation at this flow. Actual water use on the South Saskatchewan River below Lake Diefenbaker totals less than 3 m^3/s. Pollution regulations are

such that 42.5 m^3/s would be adequate for dilution of sewage effluent. Although even a lower minimum flow would have benefited project operation, a minimum daily mean flow rate of 42.5 m^3/s at Saskatoon was established.

Since the power turbines cannot operate efficiently at this low flow rate, tests were done to determine whether brief releases at higher flows and then zero releases that averaged 42.5 m^3/s over a daily cycle would have adverse effects. It was found that the river channel stored the peak releases and that fairly steady flows developed at downstream points. Therefore, instantaneous flows are not limited so long as mean daily values meet the 42.5 m^3/s flow requirement at Saskatoon.

E. AGENCIES INVOLVED IN OPERATION

Operation of Lake Diefenbaker and Tobin Lake is accomplished through co-operative efforts of several agencies.

Lake Diefenbaker is operated in accordance with Part II of the 1958 Memorandum of Agreement between the Governments of Canada and Saskatchewan which provided for the constituting of a four-member Board of Officers known as the "South Saskatchewan Reservoir Board." This Board has two members from PFRA and two provincial members, one from Saskatchewan Environment and one from the Saskatchewan Power Corporation. This Board sets the overall operating policy for operation of Lake Diefenbaker.

Saskatchewan Environment develops weekly and seasonal flow forecasts and, in consultation with the Saskatchewan Power Corporation, co-ordinates and directs the day-to-day operation planning of Lake Diefenbaker within the policy guidelines set by the Reservoir Board.

The Squaw Rapids Generating Station and Tobin Lake are owned and operated by the Saskatchewan Power Corporation. Saskatchewan Environment provides inflow forecasts and co-operates with SPC in the development of operation plans for this project.

Water Survey of Canada and the Atmospheric Environment Service of Environment Canada in Saskatchewan and Alberta provide much of the basic data for flow forecasting and monitoring operation.